The Engineer

AUGUST 14, 1953 28, ESSEX ST., STRAND, LONDON, W.C.2. TWO SHILLINGS

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Authority: BOROUGH OF SCARBOROUGH

Borough & Water Engineer:
H. V. OVERFIELD, Esq., M.I.C.E., M.I.Mun.E., M.Inst.W.E.

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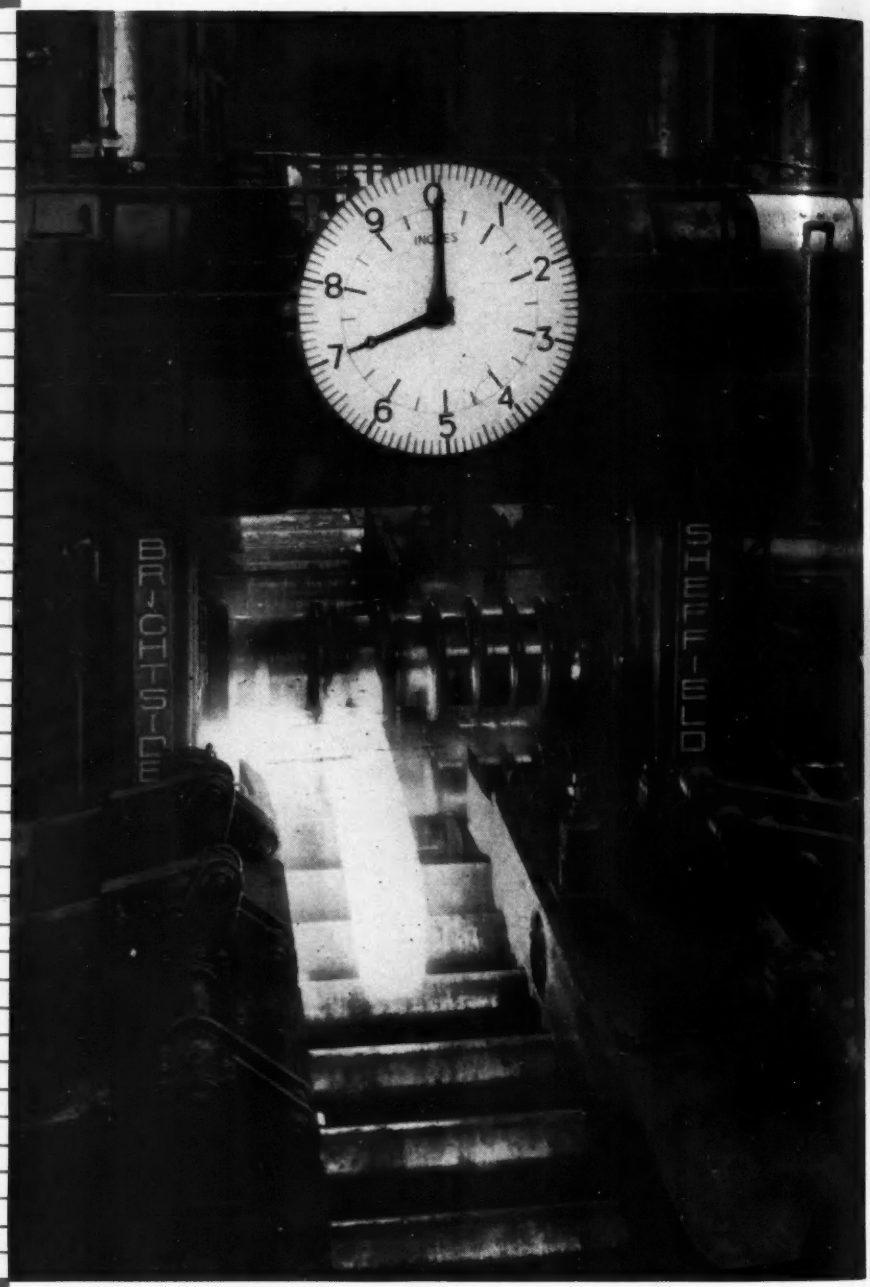

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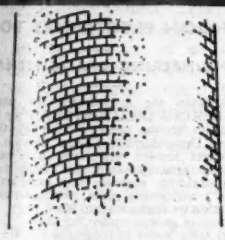

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PRINCIPAL CONTENTS

(Complete contents on page 208)

Employing Retired Engineers 208

A Short History of Spectroscopy—No. II 194
(T. W. CHALMERS)

A High Efficiency Air Cleaning Process 211
(I. M. DAVIDSON and D. R. WHITTET)

Nuclear Reactors for Electric Power Generation—No. I 196

Moments of Area of Irregular Plane Figures ... 213
(H. G. EDMUNDS)

Ultrasonic Inspection of Welded Pressure Vessels 199

The Solution of Transient Heat Flow Problems by Analogous Electrical Networks—No. I ... 217
(D. L. LAWSON and J. H. McGUIRE)

Aircraft Noise and its Remedy 208

NOTICE TO READERS

All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

INDEX TO ADVERTISERS—PAGE 127

PUBLIC APPOINTMENTS

UNIVERSITY OF MANCHESTER

(FACULTY OF TECHNOLOGY)

MANCHESTER MUNICIPAL COLLEGE OF TECHNOLOGY

APPOINTMENT OF PROFESSOR OF MUNICIPAL ENGINEERING

The City Council and the University of Manchester jointly invite applications for the PROFESSORSHIP OF MUNICIPAL ENGINEERING in the University of Manchester and in the College of Technology.

The main responsibility of the Department of Municipal Engineering is the training of students for careers in this profession, although many eventually find employment in other branches of civil engineering. It is intended to appoint a Professor whose experience and interests are such as to enable him to direct the teaching and research of the department on a sufficiently broad basis.

Salary : £1600 to £2000 per annum. Initial salary according to qualifications and experience.

Conditions of appointment and form of application may be obtained from The Registrar, College of Technology, Manchester, 1. The last day for the receipt of applications is 1st October, 1953.

Canvassing, either directly or indirectly, will disqualify a candidate for appointment.

D. CARDWELL,
Acting Principal of the College.

E9803

GLAMORGAN EDUCATION COMMITTEE

BRIDGEND TECHNICAL COLLEGE

ASSISTANT (GRADE A)

Glamorgan Education Committee : required for September, 1953, or as soon as possible thereafter, at Bridgend Technical College, an ASSISTANT (Grade A) in the engineering department, to teach English, Civics and Mathematics to mining pre-entrants at the Tynewydd Mining Centre, Ogmore Vale. Mining or engineering experience desirable.

Application forms, obtainable from the undersigned on receipt of a stamped, addressed foolscap envelope, must be returned by 22nd August, 1953. Canvassing will disqualify.

EMLYN STEPHENS,
Director of Education.

County Hall,
Cardiff.

E9791

GLAMORGAN EDUCATION COMMITTEE

BRIDGEND TECHNICAL COLLEGE

FULL-TIME ASSISTANT (GRADE A)

Required, as soon as possible at Bridgend Technical College, Full-time ASSISTANT (Grade A) in automobile engineering practice. Candidates will be required to assist with general workshop courses and must possess the Final Certificate in Automobile Engineering Practice of the City and Guilds of London Institute and/or qualifications in engineering workshop practice, together with experience in motor vehicle repair and servicing.

Application forms, obtainable from the undersigned on receipt of a stamped, addressed, foolscap envelope, must be returned by August 22nd, 1953. Canvassing will disqualify.

EMLYN STEPHENS,
Director of Education,

County Hall,
Cardiff.

E9807

PETERBOROUGH JOINT EDUCATION BOARD

PETERBOROUGH TECHNICAL COLLEGE

FULL-TIME ASSISTANT TEACHER (GRADE B)

Applications are invited for the post of Full-Time ASSISTANT TEACHER (Grade B) in the Engineering Department. The successful candidate must be able to teach production engineering subjects up to Higher National Certificate level and should have had good industrial experience. Some teaching experience is also desirable. Salary will be in accordance with the conditions of the Burnham Technical Report.

Further particulars and application form will be sent by the undersigned on receipt of a stamped, addressed, foolscap envelope. Application should be made within fourteen days of the appearance of this advertisement.

LESLIE TAIT,
Chief Education Officer.

Education Offices,
Town Hall,
Peterborough.

E9821

ROTHAMSTED EXPERIMENTAL STATION,

HARPENDEN, HERTS

Applications are invited from persons with engineering experience to supervise machinery for extracting protein and other materials from agricultural products and to co-operate in research on the project. Some knowledge of chemistry would be an advantage. The appointment is for two years in the first instance.

Pay according to qualification on the Scientific Civil Service scales.

Applications to be addressed to the Secretary.

E2282

PUBLIC APPOINTMENTS

ESSEX EDUCATION COMMITTEE

SOUTH-WEST ESSEX TECHNICAL COLLEGE,

FOREST ROAD, WALTHAMSTOW, E.17

ASSISTANT (GRADE B)

ASSISTANT (Grade B) required as soon as possible to teach mechanical engineering subjects up to Final Degree standard. Salary (male) £490 by £25 to £765 per annum, plus Degree, training and London allowances. Approved industrial experience may be recognised in assessing commencing salary.

Application (no forms), stating full details of training, qualifications and experience, to the Clerk to the Governors at the College as soon as possible.

E9818

BOROUGH OF NELSON

WATERWORKS DEPARTMENT

ENGINEERING ASSISTANTS

Applications are invited for the following appointments in the office of the Waterworks Engineer and Manager :—

(a) SENIOR CIVIL ENGINEERING ASSISTANT. Salary in accordance with A.P.T. Division, Grade V, of the National Scales of Salaries (£595–£645 per annum).

(b) JUNIOR CIVIL ENGINEERING ASSISTANT. Salary in accordance with A.P.T. Division, Grade III, of the National Scales of Salaries (£525–£570 per annum).

The appointments will be subject to termination by one month's notice on either side, the provisions of the Local Government Superannuation Act, 1937, and the successful candidates passing medical examinations.

Applicants for the post of Senior Civil Engineering Assistant should have general waterworks experience, preferably including borehole pumping machinery and reinforced concrete work, and should have passed Sections A and B of the examination of the Institution of Civil Engineers (or hold equivalent qualification).

The waterworks undertaking has some interesting work on hand and both appointments offer an opportunity to obtain useful experience in the profession.

Applications (suitably endorsed), stating age, qualifications and giving details of experience, together with copies of two recent testimonials or the names and addresses of two persons to whom reference may be made, should be delivered to the undersigned not later than Monday, the 24th August, 1953.

F. W. ROBERTS,
Town Clerk.

Town Hall,
Nelson,
30th July, 1953.

E9772

INSTITUTION OF CIVIL ENGINEERS

SECRETARY TO THE INSTITUTION

The Council invite applications for the post of SECRETARY to the Institution. The applicants must be more than 35 years of age.

The duties of the Secretary as laid down in By-law No. 93 are as follows :—

It shall be the duty of the Secretary, under the direction of the Council, to conduct the correspondence of the Institution ; to attend the meetings of the Institution, and of the Council, and of Committees ; to take minutes of the proceedings of such meetings ; to read the minutes of the preceding meeting and such communications as may be ordered to be read ; to superintend the publication of such papers as the Council may direct ; to have charge of the library ; to direct the collection of the subscriptions and the preparation of the accounts of the expenditure of the funds ; and to present all accounts to the Council for inspection and approval. He shall also engage and be responsible for all persons employed under him, and shall generally conduct the ordinary business of the Institution.

The salary will be not less than £2500 per annum, with the benefit of the Institution's Staff Pension Scheme.

Applications should be submitted as soon as possible and must be received at the Institution not later than Monday, the 19th October, 1953. They should contain full particulars of the candidate's experience and qualifications.—Applications should be addressed to the Chairman of the Selection Committee, The Institution of Civil Engineers, Great George Street, Westminster, S.W.1. E9840

LONDON ELECTRICITY BOARD

CHIEF ENGINEER'S DEPARTMENT

STRUCTURAL ASSISTANT, STRUCTURAL DRAUGHTSMAN

Applications are invited for the above positions in the Construction Branch of the Chief Engineer's Department in Central London.

Applicants for the position of structural assistant should have experience in the design and detailing of reinforced concrete heavy foundations, superstructures, and other structural works. Applicants for structural draughtsman should have experience in detailing reinforced concrete structures.

The posts are graded under Schedule "D," National Joint Board agreement, as Grade 5, £595 7s. to £704 11s., and Grade 6, £458 to £595 7s. per annum respectively, inclusive of London allowance. Commencing salary will be dependent upon qualifications and experience.

Application forms obtainable from Establishments Officer, 46, New Broad Street, E.C.2, to be returned completed by 21st August, 1953. Please enclose addressed foolscap envelope and quote ref. V/161s/EE on all correspondence. E9661

PUBLIC APPOINTMENTS

NATIONAL COAL BOARD

CENTRAL ENGINEERING ESTABLISHMENT

SUPERANNUABLE APPOINTMENTS

National Coal Board invite applications for the undermentioned superannuable appointments at their new Central Engineering Establishment, which will be located in or near the Midland coalfields.

The establishment will have two main functions :—

(a) The development of new machinery and equipment up to the prototype stage.

(b) The non-routine testing of machinery, ropes, new materials, &c.

DIRECTOR, who will be responsible for all aspects of the establishment's work. Salary will be not less than £2500 per annum. Candidates, who should be Corporate Members of the Institution of Mechanical Engineers, or equivalent, should have had experience in design over a wide field and should be able to introduce and apply known techniques from other industries to the mining industry. Preference will be given to those who have had previous experience of development work and of organising the facilities required. (Reference No. TT/671).

DEPUTY DIRECTOR (Administration), who will be responsible to the Director for the administration of the establishment and all the non-technical aspects of its management. Salary will be not less than £1500 per annum. Candidates should preferably have had experience of similar administrative and management responsibilities in connection with a technical establishment. (Reference No. TT/672.)

Write, giving full particulars (in chronological order) of age, education, qualifications and experience (with dates), to National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, marking envelope with the relevant T.T. Reference Number quoted above. Original testimonials should not be forwarded. Closing date, 28th August, 1953. E9798

CITY AND COUNTY OF KINGSTON UPON HULL

WATER DEPARTMENT

APPOINTMENT OF TECHNICAL STAFF

Applications are invited for the appointment of an ENGINEERING ASSISTANT at the maximum salary (viz., £735 per annum) of Grade VI, A.P.T. Division of the National Joint Council's Scales.

Applicants must be Corporate Members of the Institution of Mechanical Engineers and must have had considerable experience in the design and maintenance of large pumping plants.

The appointment will be subject to one month's notice on either side, to the National Scheme of Conditions of Service, to the Local Government Superannuatiin Act, 1937, and to the passing of a medical examination.

Applications, giving age, details of education, qualifications and experience, and accompanied by copies of two recent testimonials, must reach the undersigned not later than the 28th August, 1953.

T. H. JONES, M.I.C.E., M.I.W.E.,
Water Engineer and Manager.

Water Department,
Alfred Gelder Street,
Kingston upon Hull.

E9809

DORCHESTER RURAL DISTRICT COUNCIL

WATER AND SEWAGE DISPOSAL WORKS

APPOINTMENT OF FITTER-MECHANIC

Applications are invited for the above appointment at a salary in accordance with Grade V of the Miscellaneous Division of the National Scale of Salaries (£480, rising to £540), plus travelling expenses.

Housing accommodation is available.

Details of duties and application forms obtainable from the undersigned, to whom applications should be sent by not later than first post on Monday, the 24th August, 1953.

A. E. SYMES,
Clerk of the Council.

Council Offices,
58, High West Street,
Dorchester,
4th August, 1953.

E9768

SENIOR DRAUGHTSMAN

NIGERIAN GOVERNMENT RAILWAY

SENIOR DRAUGHTSMAN (Civil Engineering) required by the Nigerian Government Railway for one tour of 18 to 24 months in first instance. Salary, &c., in scale £1170, rising to £1453 a year ; gratuity £150 a year. Outfit allowance £60 ; free passages for officer and wife and assistance towards cost of children's passages or their maintenance in this country. Liberal leave on full salary. Candidates must have extensive experience in preparation of design and working drawings for railway track layouts and construction works, retaining walls, drainage and water supply schemes.

Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote M2B/29981/EH. E9804

HAMMERSMITH HOSPITAL

ENGINEERING TECHNICAL ASSISTANT

ENGINEERING TECHNICAL ASSISTANT required. Salary, £575–£675, plus London Weighting. Further particulars obtainable from Chief Engineer, Hammersmith Hospital, Du Cane Road, London, W.12. E9787

PUBLIC APPOINTMENTS

COUNTY BOROUGH OF TYNEMOUTH

WATER DEPARTMENT

ENGINEERING ASSISTANTS—GRADE AND VI

Applications are invited for the above appointments from civil engineers with considerable rience in waterworks. The salaries will be in ance with the National Salary Scales of :—

Grade IV, £555 to £600 per annum, and
Grade VI, £670 to £735 per annum.

Forms of application and conditions of ap ment may be obtained from Mr. C. F. J. Lisle, A.M.I.C.E., M.I.W.E., Water Engineer and Ma 8, Northumberland Square, North Shields, N umberland, to whom they should be returne Monday, the 24th August, 1953.

FRED. G. EGNER,
Town Cl

14, Northumberland Square,
North Shields,
27.7.53.

E9

NATIONAL COAL BOARD

MECHANISATION BRANCH OF PRODUCTION DEPARTMENT

FIELD DEMONSTRATING ENGINE

National Coal Board invite applications for superannuable appointment of a FIELD DEM STRATING ENGINEER in the Mechanisa Branch of Production Department at Headqua The selected candidate will be required to assist the installation of new mining machines, to acqu himself with their construction and method of op tion and to train personnel at the collieries in w they are installed in both operation and maintena The duties will involve spending a conside proportion of the time in the coalfields. Candi should have had good experience as fitters or me nics and be thoroughly acquainted with mo mining machinery. A recognised qualificatio Mechanical Engineering would be an advant Residence in London will not be essential.

Salary in a range £700–£1000 per annum, accor to qualifications and experience.

Write, giving full particulars (in chronolo order) of age, education, qualifications and experi (with dates), to National Coal Board, Establishm (Personnel), Hobart House, Grosvenor Place, L don, S.W.1, marking envelope TT/670. Ori testimonials should not be forwarded. Closing 29th August, 1953. E97

NORTH-WESTERN GAS BOARD

NORTH CHESHIRE AND PEAK GROU

GROUP INDUSTRIAL GAS ENGINEE

Applications are invited from trained and quali ENGINEERS for the above pensionable appo ment at a commencing salary of £1000 per annu Applicants should have full knowledge of utilisation of gas and other fuels in industrial commercial establishments, together with wide e rience of the design, development and operatio industrial and commercial gas burning equipme Detailed applications, giving the names of referees, should reach the Secretary, North-We Gas Board, 60, Whitworth Street, Manchester within fourteen days. E98

LONDON ELECTRICITY BOARD

ENGINEERING DRAUGHTSMAN

Applications are invited for the position ENGINEERING DRAUGHTSMAN for electr plant layout in the drawing-office of the C Engineer's Department in Central London.

Applicants should preferably have served engineering apprenticeship and have had technical training, together with experience in layout of transforming plant, switchgear and c for operation on voltages up to 66kV.

The post is graded under Schedule "D" of National Joint Board agreement as Grade 5, £59 to £704 11s. per annum, or Grade 6, £458 to £59 per annum. These figures are inclusive of Lon allowance, and the commencing salary will dependent upon qualifications and experience.

Application forms from Establishments Offi 46, New Broad Street, E.C.2, to be returned c pleted within seven days of the publication of advertisement. Please enclose addressed, fools envelope and quote ref. V/1580/EE on all co pondence. E983

TENDERS

INDIA STORE DEPARTMENT

STEEL WIRE

The High Commissioner for India invites T DERS for the SUPPLY of :—

Various types of STEEL WIRE for Indian R ways. Quantity, 118 tons 12 cwt.

Forms of Tender may be obtained from Director-General, India Store Department, 32 Edgware Road, London, W.2, at a fee of 10s., wh is not returnable.

Tenders are to be delivered by 2 p.m. on Fri 9th October, 1953.

Please quote Reference No. 60/53 in your appli tion. E979

THE ENGINEER

AUGUST 14, 1953

Report of the Chief Inspector of Mines for 1951

THE report for 1951 of the Chief Inspector of Mines of the Ministry of Fuel and Power has recently been published. The report states that what might have been a "good year" from the point of view of reduction in the number of persons killed and seriously injured was marred by a major disaster which occurred at Easington Colliery, Co. Durham, on May 29, 1951, when eighty-three persons lost their lives. Even so, it is stated, the total killed and injured was a low record for a year of full employment; 487 persons were killed and 1942 seriously injured. During the course of the year under review, preliminary trials on methane drainage were in progress, and the transfer of plans of abandoned coal mines and seams to the National Coal Board was completed. The various technical aspects of mine working commented upon by the chief inspector, included remarks on methods of support. The frequency with which it was necessary to criticise specifications of systems of controlling and supporting the roof and sides was a matter of concern, he noted, and it appeared that such specifications were often inadequate; various support systems were discussed at length in the report. Subsequent sections commented on precautions which should be taken to avoid explosions due to the presence of firedamp or coal dust, and fires due to various causes. The safe use of compressed air plant was also discussed, as was suffocation by natural gases and danger from water. Regarding the use of explosives, it was remarked that a high proportion of the accidents which occurred in 1951 due to the use of explosives would have been avoided if the legal requirements designed to protect the workmen had been observed. The increased usage of explosives was again proportionately greater than the increase in coal output, the inspector noted, and the coal produced per pound of explosive fell to a still lower level. It was impossible to escape the conclusion, he continued, that more shots were being fired than was really necessary and that too many shots were overcharged. The report then dealt with underground haulage and transport, accidents due to the use of electricity, shaft accidents, surface accidents, rescue services, training, dust prevention and suppression, health in mines, and on horses employed in the mines, of which there are still some 15,000. Many of those sections dealt at some length with the causes of accidents, recommended methods of working and so on, so that altogether the report is a valuable and authoritative document. It may be obtained from H.M. Stationery Office, price 2s.

The Third International Conference on Soil Mechanics

DURING next week the third international conference on soil mechanics will be in session in Zurich, Switzerland. Lectures and discussions on various topics of soil mechanics and foundation engineering will take place at the Kongresshaus throughout the week, and there will also be various social events. The second part of the conference from August 21st to 25th includes a four-day tour through Switzerland, during which various places of engineering interest will be visited. The conference will hold its final session at Lausanne on August 26th, followed by an excursion to the sites of the Grande Dixence and Mauvoisin dams. The president of the International Society of Soil Mechanics and Foundation Engineering, which is, of course, the organising body for the congress, is Dr. K. Terzaghi. Dr. Terzaghi will deliver the opening lecture of the technical sessions, which will be entitled "Fifty Years of Subsoil Exploration." A number of papers by authorities from various countries are to be presented during the course of the week. As might be expected, the Swiss contribution to the technical work of the conference is to be a particularly strong one; its emphasis is on hydro-electric schemes. The soil mechanics problems in the construction of a low head scheme, for instance, form the subject of one paper, and the closing lecture in Lausanne, to be delivered by Professor Stucky, is entitled "Foundations for Large Dams." Several of the new Swiss hydro-electric projects whose problems are to be discussed at the conference, will be visited by the congress members during the four-day tour. Other problems discussed by the conference will include airfield and road construction, the behaviour of piled foundations, a discussion on field investigation techniques, and various other subjects. The secretary of the conference is Dr. A. von Moos, Gloriastrasse 39, Zurich 6.

Transfer of the Royal Observatory

THE first stage in the transfer of the Royal Observatory from Greenwich to Herstmonceux Castle, in Sussex, has now been completed. This stage of the work consisted of the adaptation of the castle and the construction of the solar building and spectroheliograph cellar. Provision has been made for administrative offices, library, instrument rooms, records rooms, hostel accommodation, and residence for the Astronomer Royal. The second stage of the scheme will comprise the construction of the Meridian group of buildings to house a series of telescopes, including the Greenwich reversible transit circle, the Bamberg broken transit and the Melbourne reversible transit circle, all of which are to be transferred from Greenwich. In addition, provision will be made in this group for a new instrument, a photographic zenith telescope. Of the buildings in this group, that for the Greenwich instrument will be completed shortly, while contracts have been let for the photographic zenith telescope building and the Bamberg telescope building. The building to house the electrical control gear for the photographic zenith telescope has been completed. A meteorological enclosure to take rain gauges, thermometers, wind gauges and sunshine recorders has been completed. Work is due to start shortly on the equatorial group, comprising six new observatory domes to house the existing 30in and 36in reflecting telescopes, the 26in and 28in refractors and astrographic telescope. In addition, there will be a building in this group for the new Schmidt camera telescope, together with dark rooms and laboratories. Designs for a block of buildings for the time department, the nautical almanac office and the observatory and chronometer workshops are in hand. Ultimately a small block of service buildings will be erected, and the huts near the castle will be removed.

The Export of Aviation Equipment

IT has been announced by the Society of British Aircraft Constructors that aviation equipment worth more than £7,000,000 was exported last June, which exceeds by £1,500,000 the previous record figure achieved in May. The total figure for the year now stands at £31,000,000 and it is expected that the record goal of £60,000,000 will be realised for this year. The delivery of jet engine and turbo-propeller engine airliners first began this year, and already twelve have been despatched to overseas operators. Export orders which remain for these aircraft are valued at over £26,000,000. This backlog includes orders for twenty-two "Comets," forty "Viscounts," and six "Britannia" aircraft. In addition to these orders, overseas operators have options on these aircraft, which in the case of the "Comet" alone amount to 100 aircraft. The export of more conventional aircraft has also been maintained, such aircraft including the Bristol "Freighter" and the "Dove" and "Heron" feeder line machines made by the de Havilland Aircraft Company. The export of military aircraft has also increased during the year, and has included jet-propelled and piston-engined aircraft, as well as several kinds of training craft.

The Great Northern Railway (Ireland)

ON Monday last an agreement for the joint acquisition of the Great Northern Railway (Ireland) by the Governments of Northern Ireland and the Irish Republic was signed in Belfast by Mr. W. V. McCleery, the Northern Ireland Minister of Commerce, and Mr. S. Lemass, the Minister for Industry and Commerce of the Irish Republic. The negotiations, which began nearly three years ago, will result on September 1st in the establishment of the Great Northern Railway Board, which in future will administer the undertaking. On that date the purchase price of £4,500,000 (which will be borne by the two Governments in equal shares) will be paid to the company for distribution to the shareholders. The Board will consist of ten members, five from the North and five from the South of Ireland.

Oil Prices and the Development of Oil Resources

WHEN opening a new petroleum depot laid down by Shell-Mex and B.P., Ltd., at Pickering, in Yorkshire, last week, Mr. C. M. Vignoles, the managing director of the company, spoke about the increases in the prices of petroleum products which occurred in July. He pointed out that oil was a commodity that was very hard to come by and was generally found in inaccessible regions. For this reason the producing companies not only had to exploit the oil itself, but to build up whole new communities. Although much was heard of the production from the prolific areas, little was heard about the expenditure of effort and resources in the search for oil, which often came to naught. Mr. Vignoles, in giving instances of fruitless efforts in the search for oil, said that in 1951 some 39 per cent of the new wells in the United States were dry, or 17,000 wells were sunk to no purpose. To maintain an orderly and adequate flow of oil great resources were essential and work had to be carried out on a large scale. It was, he pointed out, against such a background that profits had to be viewed, for whilst the profits were large in aggregate they represented only a reasonable return per gallon of oil. A very large proportion of the profits were not devoted to dividends or reserves, but to the financing of all the essential developments which provided the only means of ensuring a really economical cost of distribution in the interest of future consumers. Mr. Vignoles went on to say that the earnings of the oil groups, of which so much was heard, were already in large measure apportioned for the essential development of improved facilities for production and distribution.

A Short History of Spectroscopy

By T. W. CHALMERS, D.Sc., M.I.Mech.E.

No. II—EXPLORATION OF THE ULTRA-VIOLET AND INFRA-RED REGIONS

(*Continued from page 168, August 7th*)

FOLLOWING Fraunhofer's discovery of the dark lines in the solar spectrum and Brewster's explanation of their origin, it became clear that there were two general types of spectra, the continuous and the line types, and that the second type could be subdivided into two classes, the bright-line or emission and the dark-line, or absorption, classes.

Summarising the facts as now known we can say that *continuous* spectra in which the colours blend without interruption into one another, as in the rainbow, are emitted by incandescent solids or liquids or by a gas under high pressure and temperature. The light from the interior of the sun, if we could perceive it by itself, would, it is believed, yield a continuous spectrum because the interior of the sun is mainly gaseous and is under high pressure and temperature.

On the other hand, *line* spectra are yielded by gases or vapours under low or moderate pressure. The bright-line or *emission* class consists of isolated coloured lines standing out against a dark background. Emission spectra are obtained from the light emitted by elements excited to luminosity by heat or otherwise. For example, when any salt of sodium is heated in the flame of a bunsen burner the sodium vapour thereby produced yields the characteristic spectrum of the element containing two closely adjacent

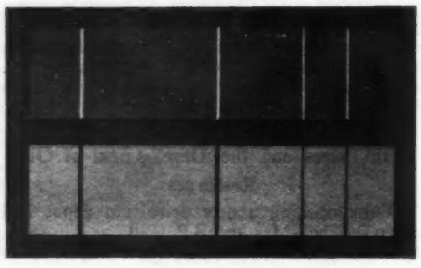


Fig. 4—Emission and Absorption Spectra of Hydrogen

strong yellow lines—together with some other much weaker lines elsewhere. These two sodium lines have received very close attention. In 1860 Kirchhoff and Bunsen, using the latter's newly invented burner as the heating agency, proved that the two yellow lines always occurred at the same place in the spectrum, whether the chloride, bromide, sulphate or carbonate of sodium was introduced into the flame. In addition they demonstrated that a change in the temperature to which the sodium salt was heated altered the intensity of the yellow lines but did not alter their positions. Modern research has fixed the positions of the two yellow sodium lines with great precision. In air at standard temperature and pressure they correspond with wavelengths of 5889·965 and 5895·932 Angstrom units*.

* In his studies of the solar spectrum the Swedish physicist, Angstrom, in 1868 found it convenient to express his results in terms of a very small subdivision of the metre. This unit is now universally adopted in many branches of physics involving minute lengths. Its value is given by 1 A.U. = 10^{-10}m, that is to say, 1 A.U. = 10^{-7}cm (or one ten-millionth of a millimetre). The Angstrom unit is frequently called the "tenth-metre." In X-ray spectroscopy the angstrom is inconveniently large and is usually replaced by the X-unit defined as 1 X.U. = 10^{-11}cm. In infra-red spectroscopy the angstrom is inconveniently small and is commonly replaced by the micron, $\mu = 10^{-4}$cm.

These sodium figures indicate the extraordinary refinement of modern spectroscopic measurements.

Dark-line, or *absorption*, spectra are obtained when a gas or vapour, instead of being excited to produce an emission spectrum, is employed as a medium between an independent source of light and the refracting prism. The gaseous or vaporous transmitting medium selects for absorption and suppression those wavelengths which the source of light if itself excited to luminosity would emit as bright lines.

By way of example the upper half of Fig. 4 shows the four bright lines in the visible portion of the hydrogen emission spectrum, while the lower half shows the four dark lines of the hydrogen absorption spectrum. The agreement in position is exact. These four hydrogen lines are now known to represent wavelengths of 6563 Angstrom units (in the visible red), 4861 (in the blue) and 4340 and 4102 (both in the violet). There is also a much fainter fifth line in the visible spectrum of hydrogen. It lies in the violet and corresponds with a wavelength of 3970 A.U. These hydrogen lines proved to be of exceptional importance in the development of spectroscopy and in its application to the elucidation of atomic structure.

Meanwhile let us complete the identification of the principal dark lines found by Fraunhofer in the solar spectrum, the lines which he labelled *A* to *H*—see Fig. 3, *ante*. Lines *A* and *B* are now known to be produced by the absorption effect of the oxygen in the earth's atmosphere. The others are produced by the absorption effect of certain elements present as gases or vapours in the sun's atmosphere. The *C* and *F* lines are two of the hydrogen series and the *E* and *G* lines are two of the very large series produced by iron. The *D* line is the sodium doublet and the *H* line is due to calcium.

Various methods can be used to excite an element into the state in which it will yield a bright line, or emission, spectrum. These different methods give rise to correspondingly named subdivisions of such spectra. A common method consists simply of heating the element or one of its salts in a flame such as that of a bunsen burner. The result is known as a flame spectrum. This method is applicable to elements which are naturally gaseous or which readily vaporise at the temperature of the flame. Higher temperatures can be obtained by passing an electric spark between two terminals surrounded by the gas or vapour. The emission spectra of gases may also be studied by passing a current of electricity through them when sealed under very low pressure in a Geisler or vacuum tube. A mercury or sodium vapour lamp provides a special instance of the application of this method to the spectroscopic study of these two readily vaporisable elements. A fourth method especially applicable to metallic elements in the solid state is to use the elements as the electrodes of an arc lamp, commonly operated in a vacuum.

In general the flame, spark, vacuum tube and arc spectra of an element are similar. The relative brightness of the lines, but not their positions, may differ according to the method of excitation employed. One method because of the higher temperature which it imparts, may render prominent lines which another method applied to the same element may reveal only faintly or not at all. For example, the flame spectrum of iron, or one of its salts, reveals only a few bright lines, but under the much more powerful excitation of the electric arc method the iron spectrum is seen to be very complex and to consist in the visible region of over a hundred lines.

* * *

Round about 1840 photography began to be used as a means of recording the spectra of light-emitting bodies. Among those associated with this development were Fox Talbot, Sir John Herschel—son of the discoverer of the infra-red rays—and E. Becquerel—father of the discoverer of radio-activity. It was realised from the start that a photographic plate was not a complete and exact substitute for the human eye so far as spectroscopy was concerned. Ritter in 1801 had shown that photo-actinic salts, such as silver chloride, were sensitive to ultra-violet rays which the eye could not see. At and beyond the red end of the spectrum the reverse was true. The coating of a photographic plate was insensitive to rays which the eye could perceive or a thermometer detect. At first therefore spectro-photography was confined to the study of spectra towards and beyond the violet end. In after years this limitation of spectro-photography was partially removed by the development of photographic plates which were sensitive to the red rays. These plates enabled records to be obtained of the start

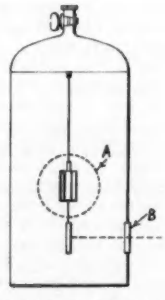


Fig. 5—Torsion Radiometer

of the infra-red region, but to this day it remains true that the complete exploration of that region cannot be effected by direct photographic means: it requires the use of very refined temperature-measuring devices. A photographic record of the indications received from these devices can, naturally, be secured, but only in that qualified sense can it be said that the complete infra-red spectrum can be "photographed."

The first important result obtained by the application of photography to the study of spectra was recorded in 1843 by Professor Draper of New York. He secured a photograph of the ultra-violet region of the solar spectrum. It showed in that region a very large number of Fraunhofer's dark lines. Fraunhofer had lettered the principal dark lines in the visible portion of the solar spectrum from *A* in the red down to *H* in the violet. Draper in order to cover the principal dark lines which he had found in the invisible ultra-violet region extended Fraunhofer's scheme of designation from *H* down to *P*. He estimated that between *H* and *P* the ultra-violet region of the solar spectrum contained as many dark lines as had been counted in the visible portion from

A to *H*—at that date about 600. It is now known that most of the principal dark lines observed by Draper in the ultra-violet region of the solar spectrum belong to the series produced by the iron vapour present in the sun's atmosphere.

The visible solar spectrum as Fraunhofer observed it with the use of a glass prism ends not far beyond the *H* line in the violet. In 1855 Helmholtz discovered that with a glass prism the visible range could be extended by a small amount into the ultra-violet region if the observer protected his eye from the light of the visible portion. Replacing the glass prism by one of quartz and shielding his eye as before, he found that the range was extended still further into the ultra-violet region and that he could actually see some of the dark lines which Draper had photographed.

In 1856 Esselbach using Helmholtz's quartz prism measured the wavelengths corresponding to the dark lines which had been detected in the ultra-violet region of

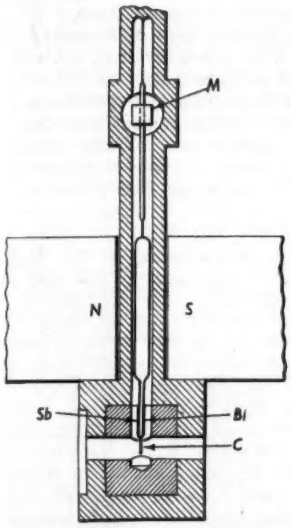


Fig. 6—Boys' Radiomicrometer

the solar spectrum. He extended Fraunhofer's alphabetical notation of the principal lines a little further than Draper had done, carrying them on from *P* to *R*. The wavelength assigned to line *R* was about 3000 A.U.

In this way during the earlier half of the nineteenth century, the dark lines in the solar spectrum were explored from *A* in the visible red down to *R* in the invisible ultra-violet or in terms of wavelength from about 7000 A.U. down to about 3000 A.U.

Meanwhile the exploration of the infra-red region of the spectrum was hanging fire. The infra-red rays could not be seen by the eye and could not be recorded on the photographic plates then available. Their heating effect provided the sole evidence of their existence and until very refined means of measuring minute heating effects had been developed their study had necessarily to lie dormant.

The "thermo-multiplier," Fig. 1, *ante*, was the first of these very refined means to be produced. It has now been developed into an instrument of extreme sensitivity. In one form or another it has been used for such diverse purposes as measuring the production of heat in a nerve and for measuring the variation in the temperature from point to point on the surface of the planet Mars.

Other types of ultra-sensitive temperature-measuring instruments have been devised, such as the vane radiometer, the radiomicrometer and the bolometer.

The vane radiometer is a development of the "light mill," which Sir William Crookes produced in 1876. As exhibited in opticians' shop windows a Crookes mill consists of a suspended four-vaned rotor, each vane being blackened on one face and polished on the other. Exposed to sunlight the rotor turns continuously. Crookes contended that the rotation was produced by the fact that light falling on a body exercises a repulsive effect on it. It is now accepted as a fact, according to both theory and experiment, that light does exert a pressure on any body on which it falls. The pressure is, however, far too small to account for the motion of Crookes' mill vanes. It is generally agreed that the motion arises from the absorption of radiation by the blackened faces of the vanes and the consequent rise in temperature in their neighbourhood relatively to that prevailing on the polished sides. As a result there is increased activity of the gaseous molecules on the blackened faces and the rotor turns under the gaseous currents that are set up.

The torsion radiometer, Fig. 5, developed from Crookes' light mill, generally has two small parallel vanes suspended in an almost completely exhausted container by means of a quartz or other fibre. Radiation reaches the vanes through a window *A*, which may be of fluorite, A second window *B*, of glass, allows light to fall on a mirror attached below the vanes. Under the action of the radiation incident on the vanes the fibre twists to a position of rest, which varies with the intensity of the radiation and which is measured by the movement of the spot of light reflected from the mirror.

The vanes of radiometers may be made of mica, aluminium foil or thin paper. In 1929 a radiometer produced at the Mount Wilson Observatory had vanes made from the wings of house-flies. The desiderata are that the suspended system should have a low moment of inertia and that the vanes should have a low degree of thermal conductivity.

The radiomicrometer, in the development of which Professor Vernon Boys played a large part in 1888, may be described as a moving-coil galvanometer with the coil consisting of a thermocouple. Boys' form of the instrument is illustrated in Fig. 6. The thermocouple element consists of two small bars, one of antimony and one of bismuth—or silver—soldered at their lower ends to a thin disc *C* of copper blackened on one face to absorb the radiation. The upper ends of the bars are joined separately to a loop of fine copper wire suspended from a glass capillary tube carrying a small mirror *M*. The tube in turn is suspended from the top of the instrument casing by a fine quartz fibre.† The thermocouple junction projects through a hole in an iron block surrounded by a copper block and through both blocks a horizontal hole is drilled to admit the radiation to the junction. The loop and its suspension system are enclosed within a copper or wooden tube in which a window is formed to admit light to the mirror. Outside the tube at its lower end are the poles of a powerful magnet.

The radiation falling on the junction heats it and generates a current in the loop and as a result the suspended system twists to an angle of rest against the torsion of the quartz fibre. The angle of twist is a measure of the intensity of the radiation and is read from the deflection of the spot of light reflected by the mirror. Boys' radiomicrometer was subsequently improved, notably by Paschen and again by Coblentz, who arranged it to operate in a vacuum. The radiomicrometer is very sensitive. Boys claimed that with it he could detect the radiation from a candle at a distance of 2 to 3 miles. For mapping the infra-red spectrum the radiation falling on the thermocouple junction is admitted through a narrow slit placed in front of it.

The bolometer was introduced by Langley in 1881 and has since been greatly improved. In principle it consists of a very thin strip of metal *A*, Fig. 7, usually platinum, which is arranged as one arm of a Wheatstone bridge. One face of the strip is blackened and on to it the radiation to be measured is allowed to fall. The bridge is initially balanced, but when the radiation falls on the strip *A* it heats it and alters its resistance, thereby upsetting the balance of the bridge. The ensuing deflection shown by the galvanometer is a measure of the intensity of the incident radiation.

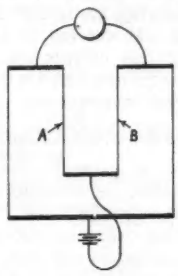


Fig. 7—The Bolometer

In his original bolometer Langley used two identical strips, *A* and *B*, and arranged them in separate arms of the bridge. One of the strips was exposed to the radiation and the other shielded from it. His object was to eliminate the effect of any change in the temperature of the room in which he made his observations. Any such change would affect both arms equally and would be cancelled out. Using strips 0·5mm broad and 0·002mm thick, Langley was able to detect temperature differences as small as one millionth of a degree Centigrade. He applied his bolometer to the study of the solar spectrum. Using lens and prisms of rock salt, he rotated the prism to make the spectrum pass across the bolometer strip. The resulting galvanometer readings were recorded on sensitised paper moved in co-ordination with the prism. In this way he was able to "photograph" the infra-red portion of the solar spectrum as far as a wavelength of 5·3 microns. In other words, if the range of wavelengths covered by the visible solar spectrum is designated as one octave, Langley carried the study of the infra-red region into the third octave beyond the red end.

Modern improvements in the bolometer have increased its sensitiveness about ten times. These improvements have mainly consisted of operating the instrument in a very high vacuum, of making the strips in the form of a grid, and of using four such grids, one in each arm of the bridge. With these improvements the study of the infra-red region of the solar spectrum was, by 1897, pushed as far as wavelengths of 23 microns or into the fifth octave beyond the visible red.

(To be continued)

† In the production of these fibres Boys displayed great ingenuity. His method involved the shooting of a very light arrow from a small cross-bow. A bead of molten glass or quartz at the end of the arrow was drawn out when the arrow was shot off. By this method Boys succeeded in producing glass threads 90ft long and 1/1000in in diameter. With quartz melted in an oxyhydrogen flame threads only 1/100,000in in diameter were produced.

Nuclear Reactors for Electric Power Generation

(By Our American Correspondent)

No. I

In its efforts to encourage private industrial participation in the power generation aspects of reactor technology, the U.S. Atomic Energy Commission is co-operating with a number of American power companies and other firms in determining the possibilities of joint production of electric energy and fissionable materials. The following notes are based on two design proposals made jointly by the Commonwealth Edison Company and the Public Service Company of Northern Illinois, and are representative of current American progress towards power generation with the aid of nuclear reactors.

THE two reactor designs described herewith were developed primarily for (1) the production of plutonium and electrical power; (2) the use of natural uranium fuel, and (3) the maximum utilisation of proven reactor technology. The gas cooled graphite-moderated reactor was chosen first since there was more information available from existing engineering, construction and operating experience. It was felt that this concept would require less extrapolation of design data and consequently less time and expense for research and development.

The Gas Cooled Reactor

As planned at present, this pile design consists essentially of two circular graphite cylinders with adjoining end faces situated parallel to each other on the same centre-line. These cylinders contain natural uranium slugs arranged in a lattice. The slug channels are parallel to the cylinder axes and are cooled by a gas which enters the system through a small gap at the centre between the two cylinders and divides its flow outward through the two reactor sections. All of the equipment is encased in a spherical steel shell to allow pressurisation.

Graphite has been chosen as the pile moderator since it provides a desirable combination of nuclear and mechanical properties and is available in the required quantities. The two cylindrical sections comprising the reactor core are each 35ft in diameter and 10ft thick, with a space at the centre for coolant gas entry. Around the periphery of each of these cylindrical sections is a belt of lower grade graphite forming the reflector. Approximately 900 tons of high-grade carbon is required in the core of the reactor and approximately 450 tons of a lower grade carbon is required in the section surrounding the core of the reactor.

In past designs of similar graphite-moderated reactors the fuel slug has been of cylindrical shape, encased in a protective coating of high purity aluminium. These reactors were all of the low temperature variety and were not suited to the extraction of heat for power generating purposes. In the proposed reactor the fuel slugs are made of uranium metal, have a central hole and are provided with fins which rest on the surfaces of the slug channels in the reactor core. It was assumed that heat is generated uniformly within the volume of the metal and the aim was to achieve a uniform heat flow from all parts of the surface. The maximum internal metal temperature was limited to 1000 deg. Fah. to prevent transformation into the uranium beta phase, which occurs at 1200 deg. Fah.

During the investigation, gases with acceptable heat-transfer characteristics were evaluated and most of them were eliminated from the design consideration because of undesirable nuclear properties or chemical instability under irradiation. Helium was selected because it is an inert gas having no chemical combination properties with uranium and having a zero neutron-absorption cross section. It has a relatively high specific heat but a very low density. Since the pumping power requirements for circulating the gas are directly proportional to the volume, pressurising the helium materially decreases the power required to transfer a fixed quantity of heat. Because of the stress limitations of the enclosing steel sphere and increased difficulties with seals and valves at higher pressures, it was decided to use an operating pressure of 10 atm. Since there is a considerable saving in gas pumping power by using only the minimum requirement of gas for each cooling channel, and since the final gas temperature must be maintained at a high value, it was considered desirable to provide restrictions in those channels where the pressure driving force in the feed slot would be higher than that required. A careful design of orifices, therefore, was necessary to maintain optimum operating conditions over the entire load range.

The dimensions of the reactor sections and the operating pressure adopted required a spherical vessel 44ft in diameter, which is illustrated in Fig. 1. Openings in the sphere permit feeding uranium into the graphite core. These openings are equipped with wear-resistant closures to prevent any loss of helium at a pressure of 10 atm. and a temperature of 750 deg. Fah. There is an opening in the lower part of the sphere for the removal of the irradiated uranium. The removal opening is connected to a channel leading into a storage canal beneath the reactor. The high activity of the irradiated uranium slugs which must be removed through the spherical shell and into submerged storage makes this area inaccessible for maintenance. The sphere has openings for the introduction and removal of the helium used to transmit the heat from the active uranium in the reactor to the boilers producing the steam for the turbine. These openings are equidistant around the graphite core to equalise the gas flow through the fuel channels in the graphite. Furthermore, there are control rod and instrument openings in the sphere. The control-rod openings are all in the top. The instrument openings are at various positions. All are blind openings made by welding capped pipes, projecting out from or into the sphere, to the wall of the sphere. The instruments can be inserted or removed by this method without sealing the openings against loss of helium, and the equipment placed in the openings is not affected by the pressure within the sphere. The external capped pipes containing the control rods are equipped with gate valves situated outside the biological shield so that the rods can be drawn up into the capped pipe, the gate valve can be closed, and the outer section of capped pipe can be removed for rod maintenance.

The sphere is made of formed and welded 1·67in thick low-alloy steel. A rectangular concrete pad about 25ft by 21ft supports it. One side face of the sphere contains seamless steel tube nipples welded inside and outside to the sphere wall. These nipples cover an area having a diameter of approximately 35ft. The opposite face of the sphere has no openings. Eighteen 24in gas inlet and thirty-six 24in gas outlet openings are arranged in three concentric rings parallel to the charging face. The inlet openings are perpendicular to the surface of the sphere with their place of centres passing through the centre of the space between the two core sections. As these 24in inlets pass through the reflector, their shape will change to a rectangle before entering the space between core sections. The gas outlet openings are arranged in two concentric rings on either side of the centre line of the inlet ducts. The entire outer surface of the sphere is sand blasted and then is metal sprayed with a 70 per cent silver—30 per cent cadium alloy. This coating is applied to reduce the neutron flux leakage at the surface of the sphere and the resultant irradiation of the air inside the biological shield. This treatment is also applied to the helium piping outside the sphere. To permit charging of the fuel channels from outside the sphere, tubes connect the end of each fuel channel in the graphite with the fittings welded in the sphere wall.

To protect the operating and maintenance personnel from radiation escaping while the reactor is in operation or after a shut-down, a shield is provided around all parts of the

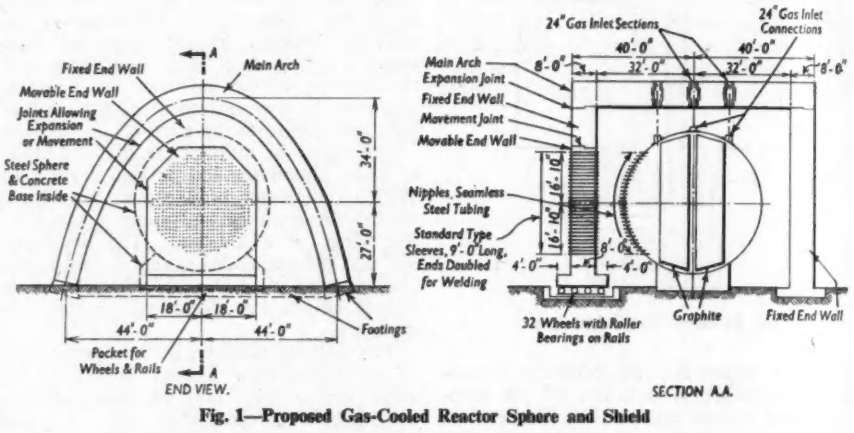


Fig. 1—Proposed Gas-Cooled Reactor Sphere and Shield

reactor installation which carry radio-active particles or may become radio-active. This radiation shield, as indicated in Fig. 1, will completely enclose the sphere containing the reactor. It is made of a crushed limestone aggregate concrete to obtain maximum resistance to heat. The shield underneath the sphere is a 10ft thick heavily reinforced concrete foundation pad. Next to the charging face of the sphere and 10ft away from it is a vertical 8ft thick concrete wall supported on rollers to move with the expansion of the charging tubes which pierce it and the sphere. At the rear of the sphere and 6ft away from it is another vertical 8ft thick concrete wall. The other two sides and the top of the sphere are enclosed by an arched 8ft thick concrete shell starting from and ending at the foundation pad. This arch extends over the outside surface of the end walls and is flush with it. The joint between the end walls and the inner surface of the arch is staggered to prevent radiation leakage. The inner surfaces of these shield walls and the floor are covered with 6in thick, 12in square, cast iron plates supported by 1in diameter steel bolts passing through a central hole in each plate. The helium leaving and entering the reactor passes through the biological shield through special duct sections, which are designed to reduce the intensity of the direct neutron beam that escapes through the ducts. Every effort is made to limit radiation leakage from the sphere shield outward and air leakage inward. The air inside the shield is hot because of the temperature of the sphere surface, the cast iron plates and the inner surface of the concrete. This temperature is used to cause the hot air to rise in a stack and maintain the interior of the shield at a negative pressure, so that all air leakage is into the shield. This leaking air becomes radio-active and requires dilution prior to discharge from the stack. The stack adjoins the rear vertical shield wall. Air passes into the side of the stack from a dampered opening in the top of the arch near the rear wall. By adjustment of the damper at this outlet of the shield structure, the airflow to the stack can be closely regulated, and this air is checked for radio-activity to provide a basis for the required flow. In addition, a ventilating system capable of providing a minimum of twelve air changes per hour is used in the reactor building.

A reactor charging and discharging system, capable of operating without reactor shutdown, is used. Without it, the availability of the electrical generating equipment would have been reduced. Also, if the entire contents of a channel need not be removed each time it is charged, the quantity of plutonium produced per pound of metal charged is increased. In operating the charging machine, the outer half of the charge in the spherical segment nearest the charging face is pushed through the graphite and becomes the outer half of the charge in the spherical segment away from the charging face. The inner half of the charge in each spherical segment of the graphite is fresh uranium identical to the outer half of the charge nearest the charging face when the new charge is installed. This sequence provides even exposure since the neutron intensity is lowest at the entering and leaving faces of the spherical sections of graphite and is greatest in the centre. The irradiated slugs drop out of the core on the far side and accumulate at the bottom of the sphere, where they are removed to the storage canal through an opening equipped with pressure locks. It is possible to charge two channels at a time by the use of a six-cylinder charging machine in a sequence operation. The charging cylinders move their charge into the sphere by helium pressure and are ejected by the internal sphere helium pressure.

The more important reactor instruments measure the power level, the reactor period, and the temperature and pressure of the heat-transfer medium, and the major control function is the operation of the control rods by manual and semi-automatic equipment. The protective devices of the reactor include automatic shut-down relays which operate when excessive radiation levels, power level, or temperatures are attained. The control rods are automatically positioned to maintain a constant helium temperature at the boiler inlet with limit supervision by the neutron flux level. They are equipped with remote indicator devices on the reactor control board to enable the operator to appraise their positions quickly. A positive means is used to move the rods wth sufficient energy storage to operate them several times for their full travel, even after an auxiliary power failure has occurred. Eight vertically mounted boron steel safety rods, which drop into holes in the reactor graphite when released by normally energised clutches, quickly stop reactor operation when any of the following situations arise :—(1) the neutron density, as indicated by suitable ionisation chambers, exceeds a safe value ; (2) the temperature of the gas leaving the reactor exceeds a safe value ; (3) the pressure in the reactor drops suddenly, indicating a leak in the helium system ; (4) the auxiliary power supply fails ; (5) the reactor period becomes shorter than the minimum value ; (6) there is loss of helium-coolant flow ; (7) a hazard is observed and one of the automatic trip buttons is operated. However, the inherent negative temperature coefficient of a helium-cooled, graphite-moderated reactor tends toward a self-protecting system. This acts to reduce the reactor activity when the coolant is reduced or stopped. Radiation leaks are detected by a group of ionisation chambers dispersed throughout the reactor building and connected to recorders and alarm circuits. These chambers are supplemented by portable instruments.

The Heat Transfer System

Helium, on circulating through the reactor, is heated and then passes through boilers where feed water is converted into superheated steam. After leaving the boilers, the helium enters gas blowers that overcome the friction drop of the elements in the cycle and return the gas to the reactor. Because of the need for multiple take-offs and returns on the reactor to keep ducts reasonable in size, twelve separate circuits, each consisting of the ducting, a boiler, and a blower, constitute the design. The relatively high helium return temperature necessitates the circulation of a large mass flow of helium to transfer the required quantities of heat. Helium flow quantities and other helium cycle data are given in the following table :—

Table I—*Helium Cycle Data*

Inlet temperature, deg. Fah.	650
Outlet temperature, deg. Fah.	384
Temperature drop, deg. Fah.	266
Specific heat of helium	1·25
Helium circulated, pounds per hour	$3·27\times10^6$
Total heat released, B.Th.U. per hour	1085×10^6
Specific volume at 384 deg. Fah., 10 atm., cubic feet per pound	15·4
Total volume (outlet), cubic feet per minute	840,000
Specific volume at 650 deg. Fah., 10 atm., cubic feet per pound	20·3
Total volume (input), cubic feet per minute	1,106,000

The boilers that absorb the heat from the helium gas are of simple design, since the gas contains no ash or incomplete combustion products to deposit on the tubes. The relatively low helium temperature of 650 deg. Fah. cannot cause overheating of ordinary steel tubes, even though the flow of water is interrupted. The boilers used are of the "straight-through" design in which the economiser, generator and superheater sections are combined into one continuous pass. A 3½in feed water line enters the shell through a thermal sleeve and connects to a 6in inlet header. From this header, forty-eight 1in O.D. tubes spaced at a 2in horizontal pitch form a bundle of forty-eight hairpin loops which are spaced at a 2in vertical pitch. These tubes terminate in an 8in steam header that extends to the outside through another thermal sleeve. There are ninety-five loops in each of the circuits. The shell is 13ft in diameter and is approximately 23ft 6in in length, having 6ft diameter flanged openings at both ends, to which the helium ducts connect. The heat-transfer system uses twelve boilers, although ten would be sufficent for the reactor power under consideration. The following table gives the boiler characteristics and the total steam flow conditions, assuming a condenser back pressure of 2·5in Hg :—

Table II—*Boiler Characteristics*

Number required	10
Steam :	
Output, pounds per hour	90,600
Temperature, deg. Fah.	525
Pressure, pounds per square inch, gauge	250
Feed water :	
Temperature, deg. Fah.	109
Pressure required, pounds per square inch	792
Helium :	
Inlet temperature, deg. Fah.	650
Outlet temperature, deg. Fah.	384
Inlet pressure, pounds per square inch absolute	147
Differential pressure, pounds per square inch	0·35
Quantity, pounds per hour	$3·27\times10^6$
Steam flow :	
Heat content of steam, B.Th.U. per pound	1276
Heat content of feed water, B.Th.U. per pound	77
Heat supplied, B.Th.U. per pound	1199
Total heat released, B.Th.U. per hour	1085×10^6
Steam flow, pounds per hour	906,000

The helium blowers used are of axial-flow design and must be operated at constant flow. Variations are only possible in increments equal to the capacity of one blower. Boiler load variations within the range of a given number of blowers are obtained by allowing deviations in the helium exit temperature. Suitable double-bellows shaft seals, to minimise any helium leakage, and bearings capable of continuous operation at 400 deg. Fah., are used. Twelve blowers, with a capacity of 75,000 cubic feet per minute each, supply the total helium flow. To improve reliability, half the blowers are steam turbine driven and the other half are motor driven. This arrangement assists in meeting the requirement of reactor cooling during shutdown. The boilers, valves and blowers are situated in the duct work circuit of the reactor. Although the helium does not become radio-active, it might contain particles of active material. Removable concrete blocks, 2ft thick, are used as shielding in this area to permit maintenance of the boilers and blowers. No radio-activity is transferred from the helium to the steam in the boilers.

Helium is continuously supplied to the blower and valve seals besides being used as a reactor coolant. Facilities are provided for helium to be stored, purified and pumped to efficient storage pressures. Underground storage tanks, occupying 45 acres, are used to store the helium, and miscellaneous buildings with a total area of 15,000 square feet are used to house the valves, controls and purifying equipment.

The Turbo-Generator

With the boiler heat input of 1085×10^6 B.Th.U. per hour, steam at 525 deg. Fah. and 265 lb per square inch absolute, and a condenser back pressure of 2·5in Hg., the calculated electric power available is given in the table overleaf.

This calculation assumes approximately half the auxiliary power to be supplied by electric

motors and half by steam turbines. Present plans call for the use of a standard 60MW turbo-generator. With a back pressure of 1in Hg. a gross output of 67·3MW can be produced. This represents a 10 per cent overload, which is the maximum allowable on standard American machines.

The control system of this reactor power plant combines the following functions:—(1) The reactor outlet helium temperature is controlled by automatic control-rod adjustment to a constant value of 750 deg. Fah. (2) The boiler rating is varied by adjusting the feed water flow. (3) The helium flow is held constant at full blower load for those boilers in service. As the boiler rating is varied the boiler outlet gas temperature changes instead of the helium quantity. (4) The boiler output determines the electric power generation. The steam temperature is allowed to vary from the design value of 525 deg. Fah. at full rating to a theoretical value of 650 deg. Fah. at zero rating. (5) The turbine control valves are adjusted by a steam pressure controller. Since it is desirable to maintain the reactor at full power rating and obtain high plutonium production even while the electric generation is reduced, a steam by-pass line to the main condenser is used. The condenser, which is designed for this service, can dissipate the total reactor heat output. This by-pass action is automatic and protects the reactor in the event of a turbine trip-out.

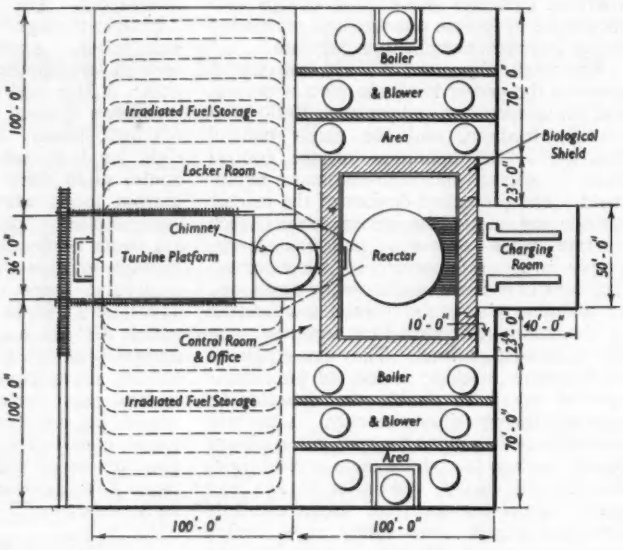


Fig. 2—Suggested Layout of Gas-Cooled Reactor Plant

TABLE III—*Power Generation*

Heat input to boilers, B.Th.U. per hour	1085×10^6
Steam flow from boilers, pounds per hour	906,000
Steam flow to auxiliaries, pounds per hour	158,500
Steam flow to turbo-generator, pounds per hour	747,500
Heat chargeable to turbine, B.Th.U. per pound	1199
Total heat chargeable to turbine, B.Th.U. per hour	895×10^6
Heat rate, B.Th.U. per kilowatt-hour	14,500
Gross generation, kilowatts	61,700
Auxiliary electric power, kilowatts	15,000
Net generation, kilowatts	46,700

A suggested plant layout is shown in Fig. 2. The boiler and reactor building is 250ft long, 100ft wide and 60ft high. An open deck, 80ft by 40ft, is used for the turbine area. Irradiated fuel underwater storage areas are situated on both sides of the turbine platform and occupy an area of 20,000 square feet, 40ft deep. The actual power station site covers an area of 100 acres.

(To be concluded)

The Elderly Engineer

By C. E. R. SAMS

IN spite of the fact of the increasing number of people over sixty (which is now about 116 per thousand), there is no more willingness on the part of the Government or of private enterprise to make use of the forty years' experience of professional chartered engineers after they have been pensioned, superannuated or dismissed because of their age.

The need of practically all elderly men able to work to keep themselves, to be suitably occupied and to live contentedly is not yet recognised.

From the point of view of the State the position is lamentable, since National Service now cuts off about two years of a man's working life at the profession he has entered or is going to enter, and at the other end—when he has great experience and is probably in perfect health—he is told he is too old and must retire. Since the value of the pound sterling is very different to what it was when he started working, this sudden cessation of occupation is calamitous. He must, in most cases, therefore vegetate, and ultimately die of frustration, ennui or premature senile decay.

If the pensionable age is sixty—as it generally is—then any man occupied in such a position should retire at sixty, otherwise he would obstruct the promotion scale; and if there is no suitable position—that is, one that is not executive—for him in that organisation, there should be available for him some occupation elsewhere where his age and experience are assets. There are many such occupations, but until the mentality of the employers is altered they will not be filled.

There is an axiom recently coined that should be recognised :—No man over sixty can fill a vacancy. Any man over sixty can fill a void.

In the first case, if such a method of employment were adopted the man would immediately block the promotion of those in that business or department waiting for the vacant post, and there would be a difficulty regarding salary, as the pensioned man could accept much less than would have been his market value just before he reached his sixtieth birthday.

In the second case since a void is a position that has not up to now been recognised, or thought of or generally adopted, when custom and prejudice are overcome there are about twenty suitable occupations and means of making use of the man's forty years' experience.

One or two examples will make this idea understandable :—

(1) A man who, after spending a few months looking about a works or factory, would then know the chief executives in the various departments. He would then devote his time to reading the technical papers, attend meetings, pay visits to other firms and observe what was going on, and instead of making a report he should analyse all he had taken notice of that might be of interest to the business, and then send to each key man a short note dealing only with what would be of interest to that man, and send to the technical director a three-line chit on any point that he considered of interest and which, if it did arouse interest, would be followed by a full report.

(2) A man who would be responsible for preventing late deliveries. He would not be an employee, but be just outside the business and be free from restraint in giving his opinion on whether the work was being carried through suitably so as to avoid delay. His position would entail visits to other firms supplying parts and would only stop at the Ministry of Supply. If he decided that the delivery date could not be kept due to any matter beyond control, he would advise the technical director so that a suitable letter could be sent to the client explaining the delay and offering a new date; but this should be done at least a month before the original delivery date elapsed, so as to give the client the opportunity of rearranging, if possible, the planned work. This procedure is seldom adopted and the reputation of the offending firm is damaged.

(3) A man to take up a temporary position of trust dealing with work he had been accustomed to do. He should not be on the staff, but given a fee for any particular assignment.

(4) A man who had done his boiler tests at college at least and probably afterwards, and who might be living anywhere in Britain, who could be made use of in preventing some part of the great waste of fuel now prevalent. The author knows of 1497 men located all over the country. So are the boilers. This number is definite, but there are probably 5000 similar unoccupied engineers.

Twenty years ago there was no problem and the elderly engineer retired on his pension or savings. Also coal was about 15s. a ton and in good supply and of good quality. To-day no man can live on his pension and few men have been able to save. Also coal is £7 a ton, if it can be obtained to keep a factory working. And yet with another coal crisis in sight and no possible means of creating a surplus, these elderly engineers, who could definitely save 15 to 20 per cent of the coal used under boilers, are not made use of to save some of this wasted fuel.

In all cases fees would be preferable to salaries, as they entail no obligation on the employer and would not cause any friction with the staff.

One letter to the *Daily Telegraph* in 1950 resulted in 1497 letters, mostly from engineers, many of them with first-class honours and all of them over sixty, and all wishing to have some occupation, all needing to augment their pension or income, and not one of them had any chance of getting any employment through answering advertisements, and no chance of an interview if they divulged their ages.

These men do not need office accommodation, they do not want office hours, they do not want to clock in and clock out, and there are more than twenty positions they can

occupy which would not carry these disadvantages.

No employment bureau has dealt, or can deal, with men over sixty, and this remark includes the Ministry of Labour as far as professional engineers are concerned. What is needed is an unorthodox bureau staffed (only two or possibly three) by men over sixty of such professional and social position as to be able to approach chairmen, managing and technical directors—and possibly ordinary directors—who are the only people who can decide or arrange to employ one or more of the unemployed discarded elderly engineers. It should not charge any fees, and at any rate at first it should be purely voluntary. Whether it could eventually become self-supporting would depend on its initial success.

It has been proved that no Government bureau can deal with such a problem, nor any existing bureaux either. This has been made abundantly clear by the evidence in 1497 letters from men who have for months and even years been trying to find some useful occupation—and they have all failed.

It is a matter that needs dealing with now and not at some future date, for each year that goes by more elderly engineers are thrown out of employment, and unless helped to get into some suitable occupation they will deteriorate and ultimately become unemployable.

The position of the artisan or mechanic—or as he is called, "engineer"—is quite different and should be dealt with through another type of bureau, but also on unorthodox lines. There should be no difficulty in arranging suitable work for these "engineers" by segregating them and arranging the work suitable for their capacities instead of the normal method of employing a man whose capacity would suit the work.

If once the basic idea of providing suitable employment for elderly professional engineers were established, all the other professions could follow suit, each providing a bureau to deal only with their particular profession, and that is why no Government bureau could have any success in dealing with men over sixty—that is all sorts of men—as it is definitely not a card index affair or a curve-making technique, which could only have any success by fitting a man into a vacant job. These men cannot be fitted into vacant jobs; it has not been done and it could not be done.

Ultrasonic Inspection of Welded Pressure Vessels

The possibilities of applying ultrasonics to the inspection of welded pressure vessels are attracting increasing attention from manufacturers and inspecting authorities. Without attempting to give a general assessment of progress in this field our article outlines the work done by one firm, W. J. Fraser and Co., Ltd., in devising ultrasonic techniques that have proved to be useful in the inspection of plates and welded pressure vessels. The following information is derived from a visit to the company's Barnsley works and from an unpublished report prepared by the company.

ALTHOUGH the use of ultrasonics for weld and plate inspection is not yet officially recognised in most codes of practice, many manufacturers and inspecting authorities are showing active interest in the development of acceptable ultrasonic testing techniques. One of the firms engaged in this work is W. J. Fraser and Co., Ltd., of Dagenham, Essex, a company that is both a contractor and a manufacturer of chemical engineering plant. This firm has had some success in devising ultrasonic techniques for detecting laminations and other planar flaws in plates thicker than ¾in and in the testing of butt welds. An interesting demonstration of the progress made in this direction was given recently during a visit to the company's Barnsley works, where pressure vessels, heat exchangers, boilers, and other items of chemical plant are manufactured.

It may be recalled that, in simple terms, ultrasonic testing makes use of the principle of echo sounding. It involves the reflection of a transmitted h.f. pulse from the remote boundary surface of the material under test and from any defects in the material. By comparing the time interval between the transmitted pulse and the echo pulses and by comparing the wave shape of the two pulses it is possible to make certain deductions as to the position, extent and nature of the defects. The information is usually presented through the medium of a trace on the screen of a cathode ray tube. Commercial equipments for ultrasonic testing have been described in the technical press and no further description is required here.[1–5]

Fig. 1—Ultrasonic Probes in Use

Ultrasonic Inspection of Plates

The echo sounding principle is applied to the testing of plates by using 30 deg. transmitting and receiving probes on the same side of the plate (Fig. 1). The ultrasonic pulse is passed into the plate through the transmitting probe and the echo pulses are picked up on the receiving probe. Any difference in the path length of the pulse appears on the cathode ray tube (Fig. 2). Thus the

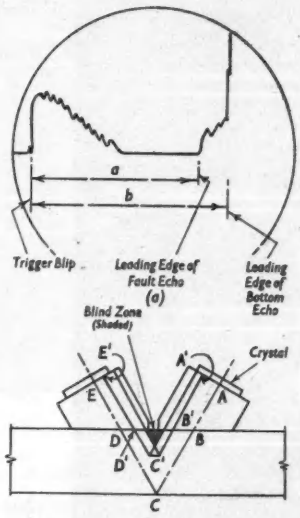


Fig. 2—Diagram Showing Typical Echo Trace

distance *b* represents a path length A B C D E and the distance *a* represents a path length A′B′C′D′E′. To give a good visual record with discrimination between the echo pulses a high sweep speed is required from the cathode ray tube.

Some precautions are necessary in the adjustment and calibration of the apparatus. For example, care should be exercised in adjusting the sensitivity of the receiver and the gap between the probes to give a sharp edge to the echo. If the power used is too high a shoulder will tend to form, giving the appearance of an echo from a flaw and if the power is too low the bottom echo will not rise sharply from the base line, making it difficult to see a shift of the echo or the formation of a shoulder. Calibration is effected with the help of a stepped plate having steps of known width and thickness to enable the position of each corresponding echo to be marked on a piece of gummed paper, for example. A typical calibration is shown in Fig. 3. In this case the maximum scanning speed of the instrument was used. It is recommended that the gap between the probes should be adjusted experimentally so that the shift of the echo is clean over the whole range of depths at which faults are likely to be met in the plate under test.

The experience of the company concerned shows that, although frequency (within limits) has little effect on the ability of the beam to detect planar flaws, it has considerable effect on the screen picture obtained. The "trigger blip" and "echo blip" (see Fig. 2 (*a*)), are pulses or bursts of short duration, each being an envelope of energy from the high-frequency oscillator, and the number of peaks visible in the sawtooth edge of the echo by the high scanning speed depends on the frequency. At a frequency of 1 Mc/s the peaks are few and give a ragged edge to the extended blip, whereas at 5 Mc/s the picture is a fine sawtooth and conducive to clear reading of the screen. For this reason the company favours the use of 5 Mc/s frequency together with appropriate coaxial cables for this frequency.

The main interest of W. J. Fraser and Co., Ltd., in ultrasonic testing of plates is in the detection of laminations such as rolled out slag inclusions of varying size in steel plate. These defects have proved to be common and they are

not easily detected except by ultrasonic techniques, when the defects occur in the body of the plate. Laminations 3 to 4 thousandths thick and, say, 1in in diameter can easily be detected. It is pointed out that smaller defects (say, ½in diameter) can also be indicated, but they may not be considered harmful, and it may be thought that the extra time spent in searching for the smaller defects is hardly worth while. In general the larger the fault that can be accepted the quicker the inspection can be carried out. More thorough inspection, however, is generally

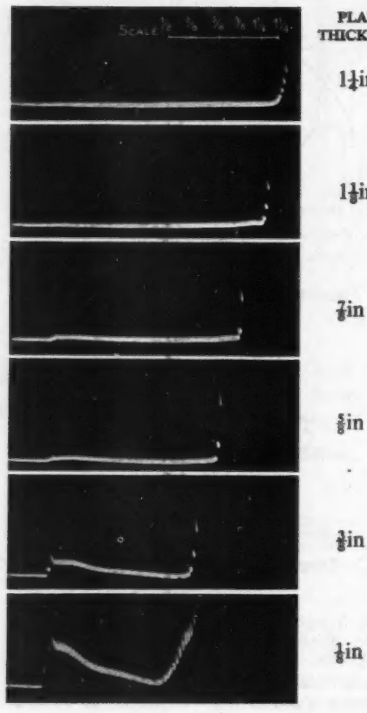


Fig. 3—Typical Calibration Obtained from Stepped Plate

justified on the important parts of plates; for example, on clad plate at knuckle radius of a dished end or on areas next to weld preparation.

The size of a fault (that is, the plane surface area presented to the beam) has an important effect on the form of the signal received. The large echo received from the bottom of the plate is the result of reflection from a surface, effectively that of the cross sectional area of the beam. A small planar fault, say, circular and about ½in diameter close to the bottom surface of, say, 1in plate, and parallel to it, would intercept the beam and return a portion of it to the receiver crystal sooner than would the bottom

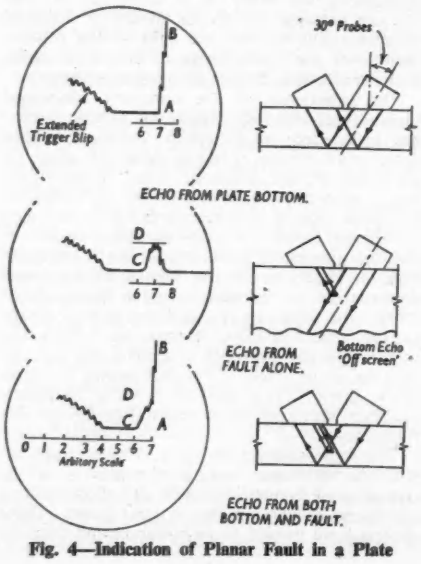


Fig. 4—Indication of Planar Fault in a Plate

of the plate, but the magnitude of this portion of the beam is considerably less than that from the bottom, and the result would be as shown in Fig. 4. The size of the small flaw may thus be estimated by the height of the shoulder CD and, as the flaw size approaches that of the crystal this shoulder rises until it gives, in effect, a complete shift of the line AB to the left (on the diagram shown this is a shift from scale position 7 to position 6). The height of a shoulder in this case cannot be used to estimate the size of the defect, and this estimate can only be made by observing the shift of the whole probe assembly required to raise the shoulder CD to the full height of the screen and drop it back to the base line. The variations of signal with probe movement is shown in Fig. 5, where progressive rise and fall of the shoulder is shown. In locating, for instance, a 3in diameter patch of lamination, as the probe assembly moves from sound plate into the lamination the shoulder CD quickly flicks up to the full height AB (giving effectively a shift of the line AB to the left) and remains there until the far limit of the lamination has been passed, then CD again falls back to the base line.

The closer the fault lies to the bottom of the plate the less the relative shift of echo along the time base and the extent of this shift gives an

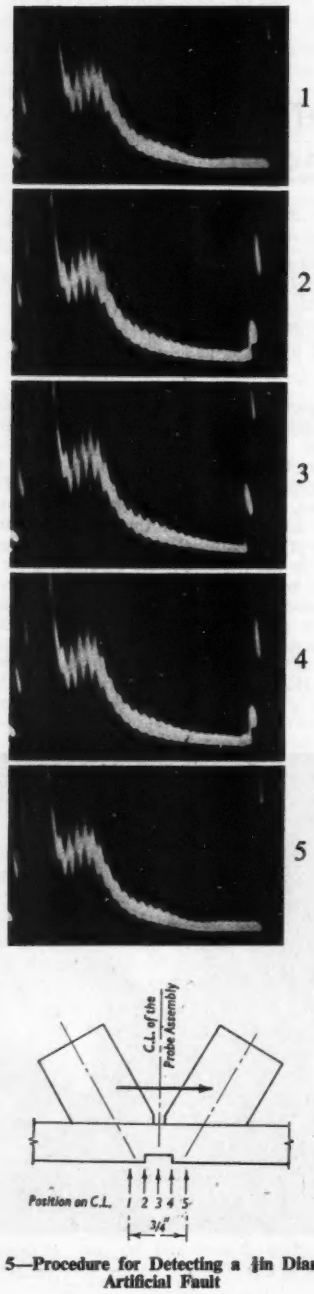


Fig. 5—Procedure for Detecting a ½in Diameter Artificial Fault

indication of the depth of the defect. The depth scale Fig. 4 is actually greater than full size and the position of faults can be determined with reasonable accuracy.

Over the whole depth range the method is not consistently accurate, since there is a triangular blind spot (Fig. 1) between the probes in which a small fault could lie and not be reached by the "booms." However, when the probes slide over a small fault which is too close to the surface to give a distinct reflection, it does cut off part of either the transmitted or reflected beam and the line CD falls away to the right. This has the same effect as loss of probe contact, but rescanning with extra pressure will soon establish the presence of a defect. In practice it has been found that faults less than ½in from the surface must be located by this means, but that at a greater depth the forming of a shoulder or a direct shift of the line AB gives a positive measurement.

The method is applicable in straightforward manner to composite plates (such as stainless clad plates). Where lack of bonding exists, the very thin discontinuity acts as a reflecting surface, as in the case of laminations and inclusions. In testing clad plate, probing is best effected from the mild steel side, since bonding is then furthest from the probing surface and, although the shifting of the line AB is not great, it is distinct and small patches (for instance, ½in diameter) of unbonded plate are detectable. Since the bonding is always at a constant distance, the shift of the line AB is constant except when a different kind of defect is encountered.

Fully comprehensive scans of plate where all sizes and depths of all defects are noted is very tedious and rarely called for in practice, but once the tolerance size and distribution of a plane defect has been established, a probing sequence or pattern can be adopted whereby the location of faults of that size can be assured. On a good surface by moving the probe on a zigzag path a square yard of plate can be inspected in about fifteen to twenty minutes, depending on the size of defect sought and the ease with which the set can be moved over the job.

Surface Condition of Plates.—Any loose scale adhering to the plate must be removed, but firmly adhering scale or simple rusting presents little difficulty. Normally a thick grease which forms a tough film and allows the probes to ride easily is used on the surface, but easier sliding can be obtained by using sheet plastic in suitable thickness with light oil on both sides. The latter technique is not so fatiguing to the operator as the use of grease films, where binding of the probe surfaces easily occurs with excess pressure.

Application of Ultrasonics to Weld Testing

Theoretically, the application of ultrasonics to butt weld inspection would appear to offer a valuable and ready method of inspection. Under experimental conditions the signals associated with various faults can be obtained in accordance with theory, but when the method is applied to production conditions the delicacy and sensitiveness of the method become troublesome. This is the chief reason why it is impossible to generalise on the value of ultrasonic weld inspection as a testing technique. The exact nature of the inspection to be performed and the limits of accuracy required must be defined. There are two important factors which retard the acceptance of ultrasonic weld inspection: first, it relies on the integrity and skill of the operator and is therefore an applied art; and secondly, it is difficult to maintain a constant and reliable surface contact.

In general, ultrasonic weld inspection involves the use of two probes. One probe transmits a beam of high-frequency mechanical vibrations which, reflecting at an acute angle between the surfaces of the plate, irradiates all the material in its path. Homogeneously fine-grained materials will not cause it to deviate appreciably, but a discontinuity, such as a fault, will reflect the sound. The detection of fault depends upon the reception of this reflected part of the original beam by a second probe and its electronic conversion to a visual "blip" on the cathode ray screen. The shape and position of the "blip" on the screen give some indication of the size and form

of the fault, behaving as a reflector, and the distance of the fault from the probe. A knowledge of the direction at which the beam enters and reflects, within the boundaries of the plate, enables a variation of signal, caused by a given probe movement to indicate to some extent the position and shape of the inspected fault. Fuller details of the techniques employed have already been published elsewhere.[4]

A 2½ Mc/s beam transmitted from the probe into a 1in plate is relatively narrow. Taking into account the simplest law of reflection, the planar fault can reflect the beam in almost any direction, depending on its orientation, permitting it to

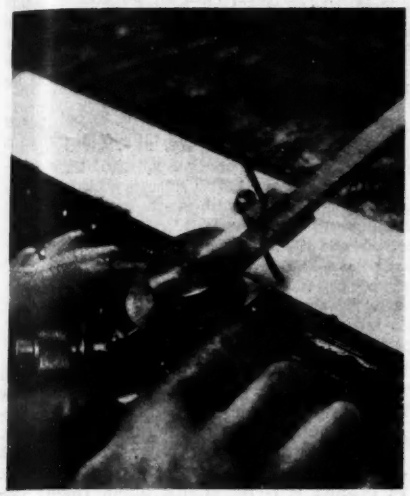


Fig. 6—Protractor Holder

emerge from the surface of the plate at a variety of points relative to the transmitting probe when viewed from above. If the fault is not to pass unnoticed, the receiver probe should be moved to cover these various points of emergence. This comprehensive movement is sometimes termed a "kidney scan," and such probe movements to ensure detection of every fault would be necessary. When approaching a weld of unknown quality this procedure is ideal, but the time involved outweighs the advantages to be gained, since all scanning must be carried out with care, bearing in mind the difficulties of surface contact. It makes a heavy demand on an operator who, with tired wrists and eyes constantly watching the screen, is carrying out the inspection of long lengths of welding.

On the assumption that few flaws are truly planar and elusively orientated, there is a good argument for a systematic examination using a single probe or two probes fixed relative to each other. The chief advantage is that fewer variables are left to the skill of the operator. The success of fixed probes depends on the relative size of flaw acceptable in the work under examination. Since few flaws are planar in practice they will usually give ultrasonic evidence of their presence, irrespective of their orientation.

In applying ultrasonics to the company's inspection problems (up to 1½in thick plates) it was decided to systematise the scanning, using one scan either side of the weld at a fixed distance and one straddle scan (a probe either side of the weld at an acute angle to it) for welds up to ¾in thick, and five scans (two either side and one straddle) for thicker welds. Later work, however, showed that a sinuous motion along the path parallel to the weld not only improved the reception of echoes but assisted in the maintenance of good surface contact. The slight additional movement did not slow down the inspection appreciably, since the probes were moved as a unit by means of a protractor holder (Fig. 6). A continuous signal plot has been made of a ¾in weld, using only single sliding motion, and another plot using the wriggling motion described. When compared with the relevant radiograph and macrosections, these plots show that at the requisite instrument settings there is good agreement with the radiographic findings.

Identification of Defects

In practice defects found are generally a combination of geometrical shapes and as such are extremely difficult to identify exactly.

Closer identification of the nature of defects can sometimes the made radiographically, but where this is not convenient it is suggested that a series of standard welds incorporating various defects should be prepared in appropriate thickness of plates: this is usually done over a period of time until a comprehensive "library" is built up. Each weld should have a radiographic record and a print or sketch kept for shop reference during inspection. By inspecting these plates ultrasonically under laboratory conditions the best instrument settings can be obtained and noted on the radiograph. After repeated runs on any one plate an operator will soon recall the fault associated with the present working conditions and the response of the equipment at any time, while working on an unknown job, can be assessed. This point is important. In actual testing it is the instinctive desire of an operator to do a run on a similar but known weld before translating signals in terms of faults on an unknown job. This procedure, although empirical and having some disadvantages, is probably one of the best ways of ensuring that variation of working conditions as a whole do not result in failure to record a significant fault.

The angle at which the beam enters the plate is usually known and its path through the plate can be drawn geometrically, taking into account

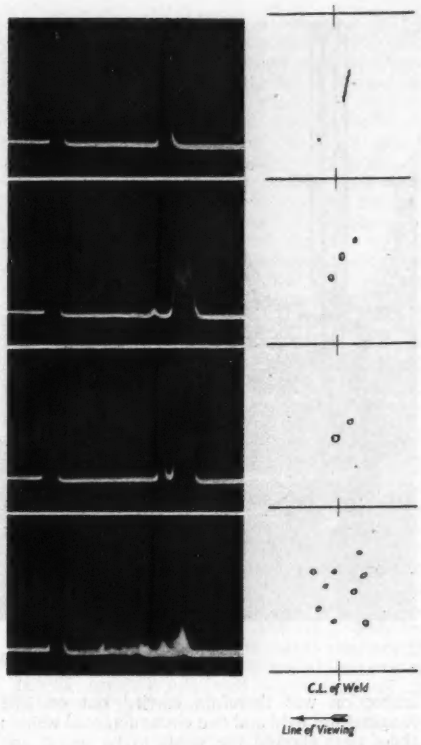


Fig. 8—Results Obtained from Typical Defects

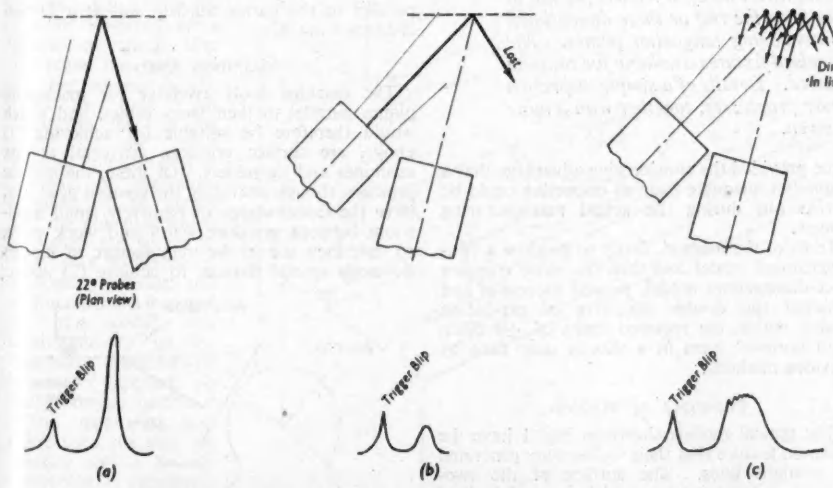
reflection between the plate faces. The distance of the fault from the probes measured along the calibrated screen and marked on the diagram gives, in theory, the exact position of the fault. In practice this can be done by eye with quick reference to a diagram of the plate under inspection, but it is more easily assessed in thicker plates where the beam does not cover the whole of the weld from any one scanning position.

Lack of weld can usually be interpreted by the incidence of a maximum echo when the probe assembly is perpendicular to the centre line of the weld (Fig. 7(*a*)), and a very rapid falling-off of the echo as the assembly is turned through a small angle (Fig. 7 (*b*)). A slag line, on the other hand, is often composed of a number of individual particles which reflect radially; the falling-off of echo is not so pronounced (Fig. 7 (*c*)). The signal should also, in theory, tend to become ragged due to difference of path length from the probe to the individual particles. This point, however, has not been convincingly demonstrated in the samples examined by the company. The results obtained with other defects are depicted in Fig. 8.

Examples of Use of Ultrasonic Testing

Two examples are given here to illustrate the kind of use that the company has made of ultrasonic testing methods. The first example concerns a fractionating column, 110ft long by 3ft 6in in diameter (Fig. 9), for an oil refinery. The two halves of this column had been radiographed during manufacture without any defects having been revealed. Some inclusions were, however, noticed in a piece of waste metal cut away to leave an entry hole. The presence of inclusions in some of the plates themselves was not considered serious, but it was felt that the welds must be above suspicion, particularly because one end of the column was to operate at about −40 deg. Cent. and that raised the possibility of notch-brittleness. Accordingly all welds were inspected ultrasonically for inclusions. The inspection proved that the inclusions were confined to certain parts of certain plates and that none of the affected areas were near the welds.

The second example involved a jacketed mixing vessel, 6ft diameter by 10ft deep. The mild steel jacket of this vessel had a test plate which was stress relieved with the jacket during manufacture. When the test piece was removed from the completed jacket it was found that there were many inclusions in the test piece, which failed below 26 tons per square inch. Ultrasonic



(*a*) Lack of penetration: signal obtained with line of viewing perpendicular to the weld centre line.
(*b*) Lack of penetration: signal falls off as probes are turned to any angle to the weld centre line.
(*c*) Line of inclusions: individual reflections when probes are turned at any angle to the weld centre line.

Fig. 7—Interpretation of Lack of Weld Penetration

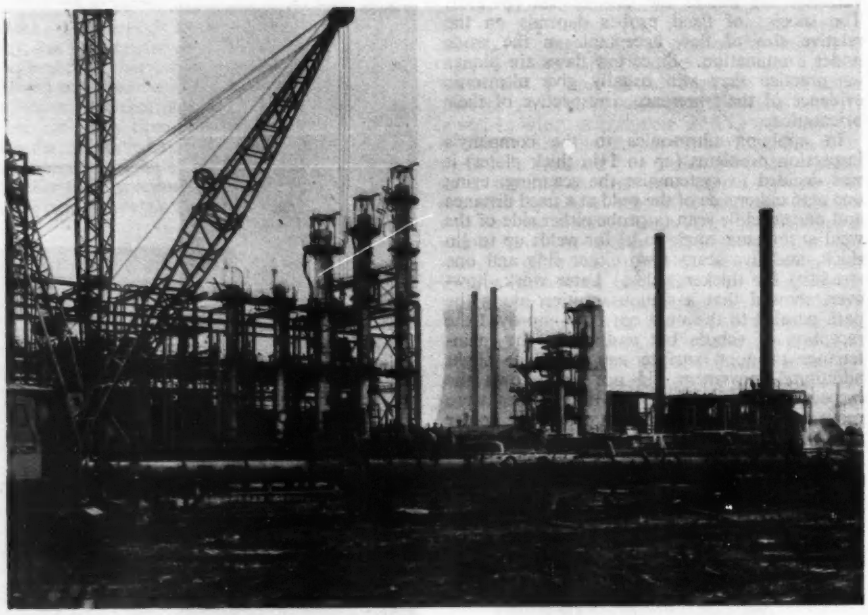


Fig. 9—Splitter Column 110ft Long by 3ft Diameter

inspection was therefore carried out on one longitudinal weld and two circumferential welds : these tests showed the welds to be sound and suggested that the inclusions were confined to the corner of the original plate from which the test piece was cut.

Conclusions

Sufficient experience has been gained by W. J. Fraser and Co., Ltd., to enable the company to make practical use of ultrasonic testing in its own manufacturing work. The method outlined for the testing of the quality of plates gives positive and reliable results. To a lesser extent this claim is true of the inspection of butt welds. Since the general sensitivity of ultrasonic equipment is higher than that of other methods, the problem invariably is that of defining what faults are permissible and to what extent they are permissible. There is marked lack of guidance in published work as to what constitutes a minimum flaw and the net result is that judgment on the side of overcaution usually results. The presentation of a radiograph enables tolerably accurate judgments to be made ; but where, as in ultrasonic testing, a physically unrelated picture of a defect is obtained without other relevant information then only the gradual building up of experience will assess the true value of this method of inspection.

In the work described here W. J. Fraser and Co., Ltd., has made use of ultrasonic test equipment supplied by Kelvin and Hughes (Industrial), Ltd.,[5] Glass Developments, Ltd., and by R. Eagon and Co., Ltd., to the designs of W. S. Atkins and Partners.

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[2] U.S. Patent 2,280,226.
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The Manufacture and Inspection of Aerofoil Models*

By R. S. MARRINER

This article describes a method of producing small metal aerofoil models for use in wind tunnels. The principle of the method is to form the two or three dimensional models required by machining a number of enveloping tangential planes. The machine tools for cutting the planes and the standard fixtures available for rotating and tilting the blank under the cutters are discussed. Details of a simple inspection technique that can be carried out as manufacture progresses, together with a more elaborate method of final inspection, are also given.

THE increased use of high-speed tunnels has led to an increasing demand for small metal aerofoils of high precision. In addition to two-dimensional aerofoils of constant section, there is a particular demand for three-dimensional aerofoils of the delta wing type where the section progressively diminishes from root to tip. Fig. 1 shows typical examples of the two types.

Experience had shown that attempts to produce the required form by methods which relied mainly on hand work failed to provide the precision required, final inspection revealing errors of form which made the models unacceptable to the limits imposed. It was therefore decided to try a machining process which would generate the form required by cutting a large number of enveloping tangential planes. Apart from its sound geometrical principle, this technique provided the considerable advantage that a simple but adequate form of inspection could be carried out during the actual manufacturing process.

Trials of the method, firstly to produce a two-dimensional model and then the more complex three-dimensional model, proved successful and achieved the double objective of producing models within the required limits of $\pm 0{\cdot}001$in from nominal form in a shorter time than by previous methods.

Principle of Method

The typical models shown in Fig. 1 have the common feature that their surfaces are generated by straight lines. The surface of the two-dimensional one is generated by a straight line, perpendicular to the root plane, which sweeps out a previously defined aerofoil section in the root plane, and the three-dimensional one is

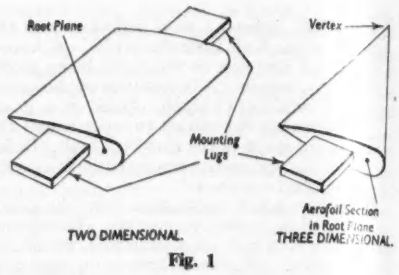


Fig. 1

generated by a straight line which passes through the vertex and sweeps out an aerofoil section in the root plane. Provided the aerofoil section has no points of inflection, each straight line generator of the surface lies in a plane which is tangential to the surface and which meets the surface only along the generating line.

The principle of the method is to cut a large number of these enveloping tangential planes in

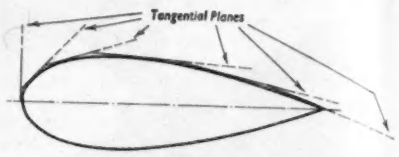


Fig. 2

an over-sized blank and, by a minimum of hand finishing, remove the slight excess metal at the inter-sections of consecutive planes, thus ensuring a smooth blending of the tangential planes. Fig. 2 shows diagrammatically a section through a model with a number of tangential planes. In practice it is found that about twenty tangential planes per side are sufficient to produce a model, leaving only a few ten thousandths of an inch excess metal at the successive intersections.

The practical problem of cutting these enveloping tangential planes can be resolved into :—

(1) Providing a means of cutting a plane parallel to, and at any required distance from, a datum surface.

(2) Presenting the blank to the cutter in such an aspect that any specified tangential plane is

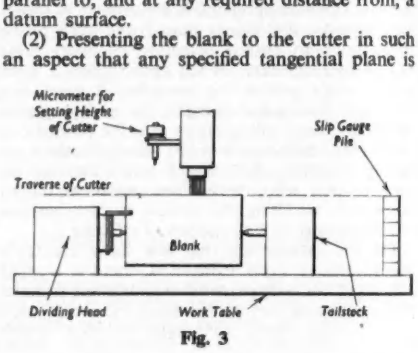


Fig. 3

parallel to the datum surface and at a known distance from it.

Machines Used

The machine tools available for machining planes parallel to their work tables, and which would therefore be suitable for achieving (1) above, are surface grinders, universal milling machines and jig millers. Of these, the surface grinders, though providing the greatest accuracy, have the disadvantage of relatively small head-room between grinding wheel and work table, so that their use in the manufacture of models demands special fixtures to achieve (2) above.

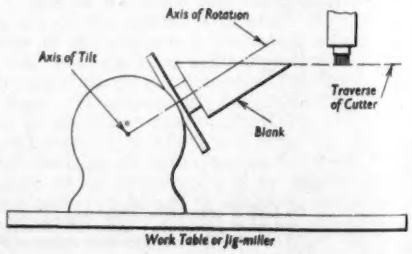


Fig. 4

* Communication from the National Physical Laboratory.

To avoid the delays which the manufacture of such fixtures would require, milling methods were used in the initial trials.

To produce two-dimensional models the blank is mounted between the head and tail-stock centres of an optical dividing head which is mounted on the work table of a universal milling machine, as shown schematically in Fig. 3. The previously calculated rotation of the blank required to bring any specified tangential plane parallel to the work table is set by means of the dividing head. By the simple means of attaching a micrometer head to the milling head, in such a way that it can be made to register on a slip gauge pile standing on the work table, the cutter can be set to the previously calculated height above the line of centres. An advantage of this arrangement, when making symmetrical models of the type shown in Fig. 1, is that for any given height setting two tangential planes symmetrically disposed with respect to the plane of symmetry can be cut by simple rotation of the blank. In this way the two surfaces are generated together and distortion of the model due to cutting stresses is minimised.

To produce three-dimensional models, in addition to setting the cutter at the required height and rotating the blank to the correct azimuth for each tangential plane, it is necessary to tilt the line of centres to produce the required tapering from root to tip. This tilt varies for each plane but is easily calculated from the known geometry of the model required and the constants of the set-up. To obtain these tilts in addition to the precise rotation, use can be made of one of the standard types of compound tables, comprising a rotary table which can be inclined about an axis parallel to its face. For the work carried out at the laboratory such a tilting rotary table, type P1–4 made by Société Genevoise, was available. Such tilting rotary tables have the necessary precision but the disadvantage that, when set up for this work, the head-room and size of table required is more than is available on standard surface grinders or universal millers. For this reason, the production of three-dimensional models at the laboratory has been carried out on a Bryant-Symmons jig-borer which, by the addition of a power feed to the work table, has been used as a jig-miller. Fig. 4 shows diagrammatically the arrangement for producing three-dimensional models.

It will be appreciated from the description of the method of manufacture that inspection of the model can proceed step by step with manufacture. It is merely necessary, after each plane is cut, to check the angular settings and then by means of slip gauges and a dial indicator mounted on a stand, to check that the plane has been cut at the correct height from the base. An allowance has to be made for the small amount of metal that is removed in the final blending of the planes and the polishing which is carried out by hand. That this allowance is sufficiently constant and within the limits imposed for the model, was established by an independent method of inspection applied to the prototype models.

The measuring machine used for this inspection was a Société Genevoise universal measuring machine, type MU214B. This machine has a horizontal work table which can be rotated precisely and at the same time translated longitudinally. Above the work table is mounted a microscope which sights on to the work table and which can be transversed vertically and also transversely to the longitudinal movement of the work table. Thus the longitudinal movement of the work table and the vertical and transverse movements of the microscope, all of which can be measured precisely, form a mutually perpendicular system of co-ordinate axes. To check the form of any section of a model the latter is mounted on the work table by means of a large lug integral with the model and machined precisely flat and parallel within 0·0001in during the initial preparation of the blank. Fig. 5 shows the arrangement for final inspection. The precision of the lug ensures that the plane of symmetry of the model is parallel to the plane of the horizontal traverses of the machine and by adjustment of the rotatable table the base chord of the model is brought parallel to one of the horizontal movements. By suitable adjustment of the horizontal movements any point of the surface, along any specified section of the model, can be brought under the microscope. The vertical movement of the microscope is now adjusted until the surface of the model at the centre of the field of view is in focus. This is facilitated by using in the microscope a special objective which has a very small depth of focus and enables vertical settings of the microscope, on any particular point, to be repeated within an accuracy of 0·0002in. After completing measurements on one side of the model it is turned over and relocated. The precision of the mounting lug allows of the measurements of the second surface being precisely related to those made on the first surface. By comparing the measured half-thicknesses of the model with calculated nominal values, graphs giving the departure from nominal form of each surface at specified sections may be obtained.

Conclusion

Since the production of the first trial models which were solid, others have been made successfully with special features such as pressure plotting tubes and a hinged tail plane for flutter experiments. In addition, a roughing jig has been introduced which facilitates the early stages of manufacture, together with an adjustable height gauge to avoid the use of slip gauges.

The high precision of the form required naturally suggests that the models should be made by grinding and the design of special fixtures to obtain the necessary rotation and tilt of a blank in the relatively small space under the wheel of a surface grinder is being pursued. In this connection it was learned subsequent to the completion of the initial trials by milling that Messrs. Rawlings and Partners, Kenilworth, Warwick, had independently and with complete success applied a similar technique to the manufacture of aerofoil models by grinding. With the experience gained from milling models and the benefit of discussions with Mr. Rawlings, it is proposed to grind hardened steel models at the laboratory.

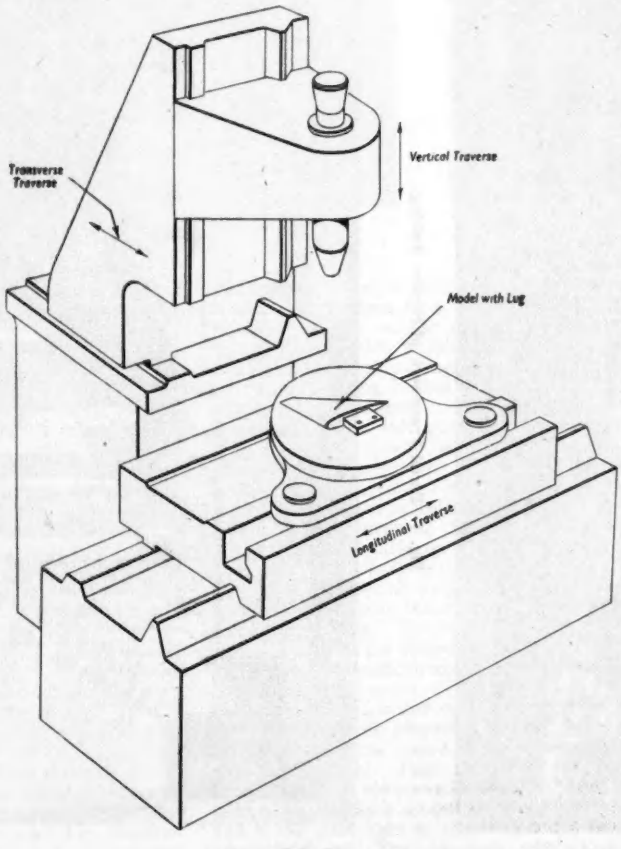


Fig. 5

Acknowledgments

The author wishes to acknowledge the assistance rendered by Messrs. W. Haywood and J. S. Wreford who machined a number of models, Miss E. Love, who computed the setting data, and Mr. G. Robinson, whose optical modification of the measuring machine simplified final inspection. In particular the author is indebted to Dr. J. C. Evans, whose advice and support made this work possible. The work described above has been carried out as part of the research programme of the National Physical Laboratory, and this article is published by permission of the Director of the Laboratory.

The Fourth International Astronautical Congress

At the fourth International Astronautical Congress held in Zurich from August 2nd to 8th papers were presented which ranged from speculative uses of atomic energy for ion rockets to a note of caution from American rocket workers such as M. W. Rosen and R. B. Snodgrass, of the Naval Research Laboratory. They warned that the margin for error as ascertained from practical work with high-altitude rockets was not sufficiently close. With many published projects this practical difficulty had not been allowed for and the difference was great enough to change success to failure in any interplanetary mission.

A similar note of caution was sounded by K. R. Stehling, of Princeton University. He doubted that optical-video and micro-wave radar scanning units would be able to be incorporated in a small instrumented rocket of the orbital vehicle type if they were designed to detect a hypothetical target of 600 yards diameter from a satellite in a 500 miles orbit.

Professor Dr. K. Schutte (Germany) said that orbital calculations were much different from engineering problems in that they can be solved now. This is because they do not depend upon technical processes, but only upon the extensive though well-tried calculations of celestial mechanics. While these are tedious, they are nevertheless still capable of solution and the laborious arithmetical work is now eased by electronic computers. Similar mathematical papers were presented by Dr. Ing. J. M. J. Kooy and Dipl. Ing. Cardoza, of Holland.

A minimum satellite rocket was discussed by Dr. S. F. Singer (England). He indicated that an instrumented earth-satellite vehicle was the logical development from present-day high-altitude rockets.

Also from England was the paper by W. N. Neat, which discussed the limitations on the performance of chemical rockets in astronautics. Again, it was a cautious paper indicating that chemical rockets can only enable mankind to aspire to the lesser interplanetary journeys and then only at enormous expense, both in money and materials.

Lieut.-Commander F. C. Durant, president of the American Rocket Society, was elected president of the International Astronautical Federation for the coming year in place of Dr. E. Sänger, who had retired from office. Seventeen societies from thirteen countries are now members of the Federation.

A PETROLEUM DISTRIBUTION DEPOT

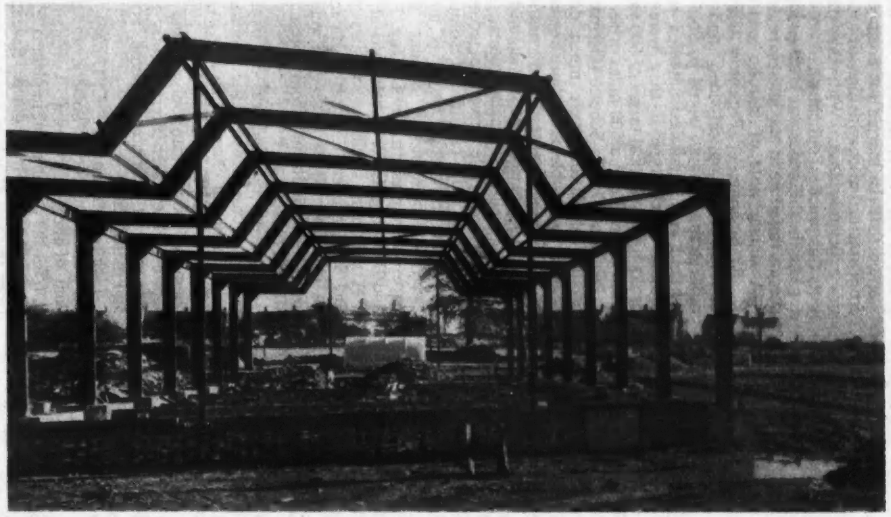


Fig. 1—Portal Framework of Service Building

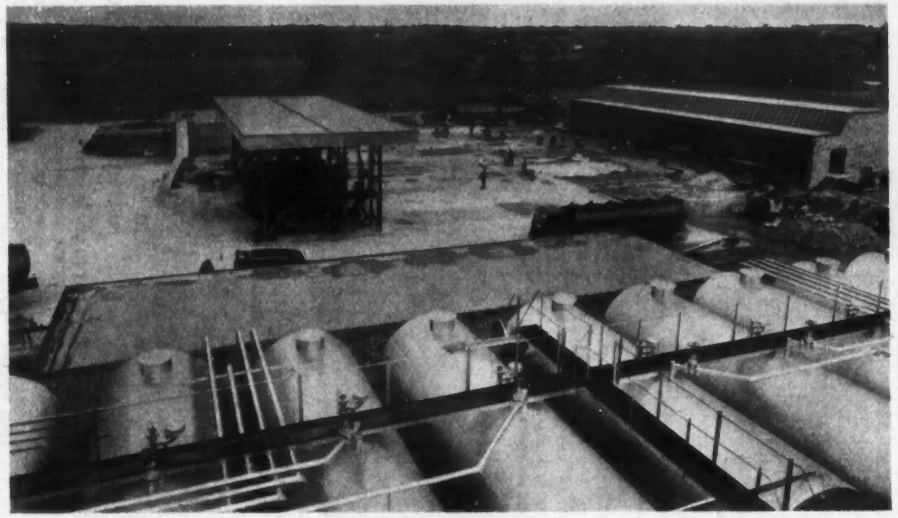


Fig. 2—Yard Under Construction

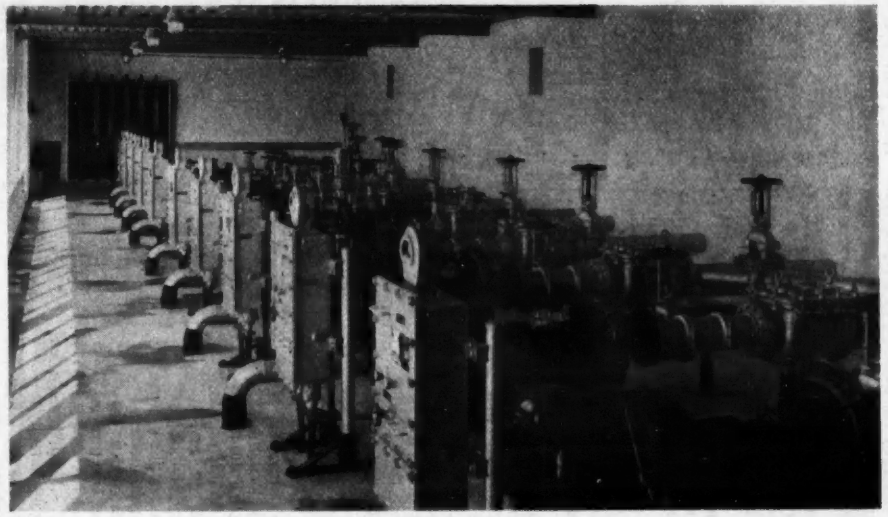


Fig. 3—Interior of Pump House

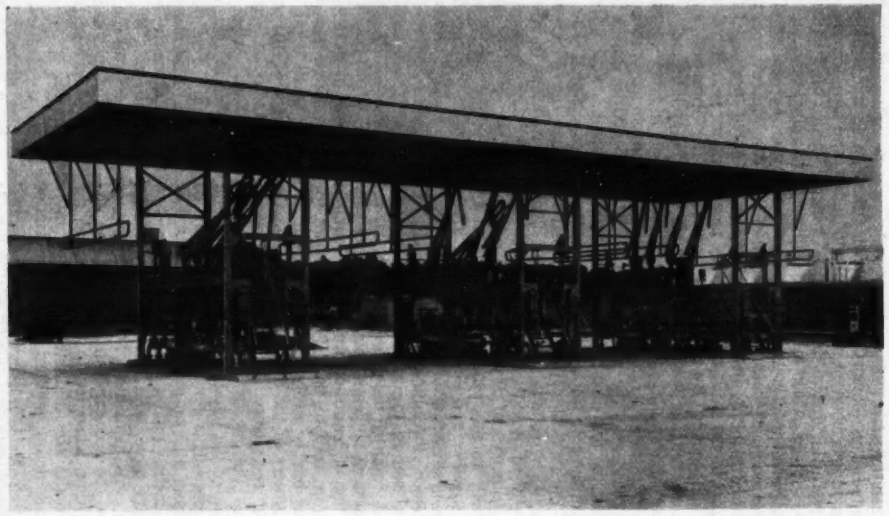


Fig. 4—Six-Vehicle Loading Gantry

A Petroleum Distribution Depot

OUR illustrations opposite show a petroleum distribution centre which was opened last week at Pickering by Shell-Mex and B.P., Ltd., to serve an area normally fed from depots at Scarborough, Whitby, Malton and York. Before site work began and after the sizes of the main buildings had been agreed, the site was planned with the aid of plastic blocks representing the buildings to scale. These were manipulated together with models of equipment and vehicles before the relative positions and the most efficient disposition of the depot facilities were established.

The depot has two wide gateways to permit an in and out flow of traffic. Between the entrance and the exit is the main administrative block. The full length of two sides of the building is of glass to admit as much daylight as possible.

The largest building in the depot combines a vehicle servicing bay with a lubricating oil packaging centre. It has a steel portal-frame, which is shown in Fig. 1, and the roof has been specially constructed to give the maximum amount of natural lighting. Facing bricks are used on the gables and walls and folding doors along the whole frontage provide the maximum accessibility.

The floor of the lubricating oil section is the same height as the tailboard of the vehicle, for convenience in loading and unloading. Many different grades are received and stored in packages here. Others are received in bulk and pumped into overhead tanks from which packages can be filled automatically through flow meters. An automatic oil-fired heating system has been installed below floor level, which heats not only this large building but also the administrative block.

To service the vehicles here are bays for washing, general maintenance and greasing, and one for inspection and running repairs. Recessed lighting is fitted in the inspection pit and the servicing equipment provides for pressure greasing, power washing, and includes a multi-point air compressor. A further bay in this section houses the general stores and also provides accommodation for a pump and tank filler.

The storage compound contains two vertical tanks, each holding 86,000 gallons, and fourteen horizontal tanks, some of which can be seen in Fig. 2, each of 12,000 gallons. Adjoining the tank compound is a small spirit store for special grades which are not held in bulk.

The main pump house (Fig. 3) contains ten motor-driven centrifugal pumps, each delivering 250 gallons a minute and controlled by push-button switches on the filling gantry. There is also a small screw displacement stripper pump for general duties.

The road tank wagon filling structure, shown in Figs. 2 and 4, occupies an island in the centre of the yard. Six wagons at once can be filled under cover and as the gantry is fed by a separate pump for each product there is no risk of contamination. There are twelve separate outlets, each with a filter, air separator, positive displacement meter and a spring-balanced loading arm. Products dispensed from this depot include motor spirit (premier and regular grades), derv fuel, gas oil, tractor vaporising oil, burning oil and lubricants.

The yard gives ample turning space for the largest vehicle. Both yard and tank compound are floodlit at night and two-way loudspeakers link the offices with the filling gantry, tank compound and lubricating oil package building. The electric power and lighting systems are of approved pattern and conform to British Standard requirements.

The architects concerned were Boissevain and Osmond, London; and the main contractors were George Longden and Sons, Ltd., Sheffield.

A Biscuit Oven for Brazil

A BISCUIT oven which is thought to be the largest in Brazil has recently been brought into service at the works of Francia and Cia., Ltda., in Rio de Janeiro. It consists of a travelling three-tray electrically heated oven, 7ft wide and 48ft long, as illustrated herewith. In an eight-hour working day this oven has a baking capacity of 5 tons of "cream crackers" and water biscuits.

Heating is provided by eight separately controlled banks of heating elements extending across the width of the oven and arranged four above and four below the conveyor. These elements are made of coiled "Nichrome" wire supported in porcelain cleats carried on a bar, and they are easily removable from the side of the oven. To reduce heat losses during maintenance the busbars have been arranged in a chamber on the outside of the oven's inner casing so that, when withdrawing an element it is only necessary to remove a cover plate and a portion of lagging behind it. Each bank of elements has a mercury-in-steel indication controller with a rigid bulb extending into the oven, together with a suitable relay, pilot lamp and control push-button switch which works in conjunction with the relay so that any or all of the heated sections can be cut out if required independently of the main oil circuit breaker.

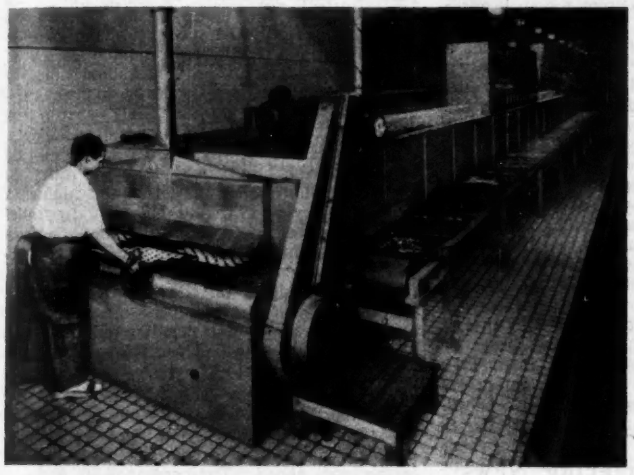
Controllers are fitted on the side of the oven near the centres of the sections they control and the rest of the control equipment is mounted on a central panel above the oven, as shown in our second illustration. The indicator of each controller is set for the temperature required, and as soon as the temperature tends to rise above this point the control circuit is broken, the current to that particular section being switched off by an air-break contactor. When the temperature falls the current is automatically switched on again. There are eight green pilot lamps indicating the operation of the contactors controlling the eight separately heated sections, and a red pilot light to show when the main switch is closed. The contactors, with a series of handguard fuses for each section are mounted in steel plate cubicles carried above the control panel. As shown on the extreme right of our second illustration, there is a wall-mounted triple-pole main oil circuit breaker with a rupturing capacity of 15MVA at 400 volts; it is fitted with overload protection, a neutral link and auxiliary switch, no-volt coil and a 6in dial moving-iron ammeter and voltmeter. The no-volt coil and the auxiliary switch are connected in series with the interlock switches on each of the contactor cubicle doors, so that access to the contactor cubicle is impossible unless the main oil circuit breaker is open, isolating the whole installation from the mains. The main and neutral lines from the oil circuit breaker feed direct to the busbars in the contactor cubicle. The contactor cubicle also houses the control gear for the 2 h.p. drive motor and all of the fuses on the installation, with the exception of two in the oil circuit breaker.

The oven body is of double case construction. The inner case is slung from the outer framework by a system of suspension bolts, so that there is a minimum of through-metal and radiation losses are consequently kept as low as possible. A space of 9/12in between the inner and outer casings is packed with mineral wool to prevent heat loss. To counteract the varying expansion of the inner and outer casings expansion joints are arranged at intervals.

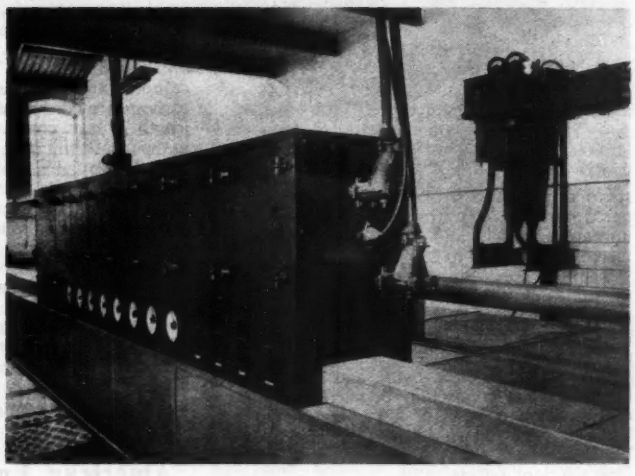
The conveyor runs straight through the oven and returns underneath and outside it. It consists of six heavy link roller chains of the Renold pattern with "camel back" sides which support the three 2ft wide trays in the width of the oven. The whole weight of the conveyor and charge is taken on channel irons, in which the chains run, and these channels are supported at frequent intervals, the load eventually being transferred to rolled steel channels supporting the oven casing.

The driving gear for the conveyor consists of a 2 h.p. totally enclosed, squirrel-cage induction motor, driving through variable reduction gears arranged at the biscuit discharge end of the oven, the final drive to the main conveyor chain shaft being by chains and wheels. The range of baking times obtainable through the variable reduction gear is arranged as required by Francia and Cia., Ltda., within the limits of 3½–20 minutes. Drop-down doors are provided at each end of the oven.

The oven described above was erected on site by Francia and Cia., Ltda., under the supervision of Drake Do Brasil S.A., agent in Brazil for the General Electric Company, Ltd., the manufacturer of the oven equipment.



Loading End of Biscuit Oven



Control Panel and Circuit Breaker

SHOCKLESS POWER TRANSMISSION.—Compression Ignition, Ltd., Twickenham, Middlesex, has published a brochure with the title "Shockless Power Transmission," which gives a technical survey of the company's "Twinflex" automatic couplings. The booklet describes how the coupling absorbs shock and damps torsional vibration and discusses its slip characteristics.

Geared Inclinable Press

THE largest of a range of inclinable power presses with adjustable stroke and of 10, 18, 28 and 40 tons capacity, respectively, made by F. J. Edwards, Ltd., 359, Euston Road, London, N.W.1, is now available as a geared machine. This press is driven by a 5 h.p., 1440 r.p.m. motor, and has the same maximum power rating of 40 tons as the ungeared model. With it the work capacity per stroke is increased at the reduced

40-Ton Geared Press

speed of forty-five strokes per minute, as compared with the 100 strokes per minute on the ungeared model, and the flywheel speed is increased from 100 to 230 r.p.m.

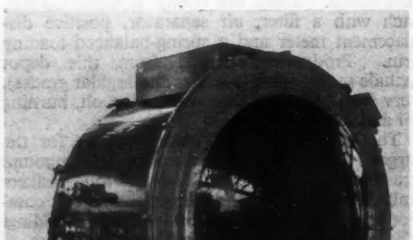
The new press, illustrated above, has a length of stroke adjustable from ½in to 3½in, and adjustments are made at an eccentric bush fitted to the split-sleeve pitman. This bush carries a flange engraved with the stroke lengths, and is simply turned to the required figure and secured by a locknut. The connection between the pitman and the ram consists of a ball-end screw and locknut. The screw, which is machined with a buttress thread, incorporates an adjustment of 2½in for tool setting.

The maximum clearance between ram face and bed, with stroke down and ram adjustment up, is 11in. The bed is just under 24in by 17in and has a 11½in by 9in centre hole. A spring-adjusted friction damper in the drive prevents over-running, and a safety pawl is incorporated to prevent reverse rotation. The treadle-operated, roller-key clutch engages in a hardened seat in the flywheel hub, and it can be set to give either non-repeating or continuous operation.

A 120cm Naval Searchlight

OUR illustration shows a 120cm searchlight which is the first of three to be completed for Vickers Armstrongs, Ltd., Barrow-in-Furness, by the London Electric Firm, Ltd., South Croydon, Surrey. It is the largest equipment of its kind designed and made by this company. It has a nominal mirror diameter of 120cm, stands 9ft high and weighs 2½ tons.

Orientation of the searchlight is electronically controlled through remote power control equipment supplied by Vickers Armstrongs, Ltd., and laying of the searchlight can be effected automatically from the ship's fire control equipment either by radar or by telescope. In its general design the searchlight is orthodox. A high intensity arc lamp is used and it operates with a working current of 150A. Provision is made



120cm Naval Searchlight

for hand feed as an alternative to automatic feed of the carbon. When running under automatic control both positive and negative carbons are fed forward to compensate for their rates of burning and, as is usual, the positive carbon is rotated, to produce, as far as is possible, a symmetrical crater. The feed rates of the two carbons are so arranged that, although the carbons are consumed at different rates, the arc length is kept constant and the crater remains at the focal point of the mirror.

Both traversing and elevating movements are driven by motors running at 6000 r.p.m. Stops are fitted to prevent over-run of the elevating and depressing movements of the searchlight, the motors and gear drive being such that the searchlight can be driven at full power on to the stops without damaging the mechanism. The searchlight is fitted with a motor-driven iris shutter, which is automatically closed by means of a "banking switch" when the beam is traversed over a specified safety arc. This arrangement ensures that the ship cannot be illuminated by its own searchlight.

American Engineering News

(By Our American Correspondent)

The New Jersey Turnpike

The annual report for 1952 issued by the New Jersey Turnpike Authority indicates that the use of the road in the course of the last year surpassed the most optimistic expectations and far exceeded the original estimates of the traffic and revenue engineers. The actual traffic carried in the first year, on the basis of the estimates, was that predicted for 1968, or sixteen years hence. The revenues produced from the traffic and concessions were equal to those predicted by the consultants for 1967. A total of 18,239,527 vehicles used the turnpike in 1952, a daily average of 49,834. The estimates of the consultants, made in 1949 for the purposes of financing the scheme, were that 7,600,000 vehicles would use the road in 1952, a daily average of 20,765. Significantly, truck traffic exceeded the original estimates of the engineers, running 231 per cent ahead in volume and 76 per cent ahead in revenue. The passenger car volume was higher by 125 per cent and the revenue from passenger car tolls was 129 per cent greater than predicted. The extent of new traffic generated by the turnpike was shown by counts which were made at specific areas on the parallel U.S. highway routes 1 and 130 in 1951, before the turnpike came into operation. During the first week of November, 1952, for example, the traffic on route 1, in Linden, New Jersey, was 332,416 vehicles, against 407,000 in the same week in 1951; a reduction, without allowing for the nation-wide increase of traffic in 1952, of 74,584 vehicles, or 18 per cent. These latter figures obviously represent the diversion of traffic from, or relief offered to, route 1 by the turnpike. At other sections of the turnpike the diversion also has been substantial, and, without regard to newly induced traffic, indicates that the turnpike has made a very great contribution to the relief of congestion on the New Jersey public highway system.

Safety on the turnpike has been one of the prime objectives of the Authority. Extraordinarily heavy fog conditions, together with smoke from nearby industrial areas in Newark resulted in several "chain-reaction" accidents in November, 1952, because of extremely low visibility. There had been no such serious accidents in this area prior to that time and the Authority took prompt steps in an effort to prevent recurrences. While for months special 35 m.p.h. signs had been placed in position during fog or other inclement weather it became apparent that these were not clearly visible in the extreme "smog" that blanketed the turnpike on those critical November days. New neon signs were developed and the first of these erected in a matter of weeks. A number of such signs between New Brunswick and the George Washington Bridge interchange are now being erected. These signs will also be erected on other stretches of the turnpike where heavy fog is likely to occur. The accidents on the turnpike in 1952 were equal to 92·7 for each 100 million miles of vehicular travel, which is the standard basis used by federal and state governments and the National Safety Council to place all American highways on a truly comparable basis regardless of length or areas traversed. The 92·7 figure for the turnpike was less than one-fifth the record for the parallel highway (routes 1 and 130) in New Jersey in 1951 of 484 accidents per 100 million miles of travel. For all of the New Jersey highways the accidents were 381 on this basis. From the standpoint of injuries sustained in accidents, the turnpike record was 108·6 per 100 million vehicle miles. This would compare with 220 per 100 million miles on all public highways in New Jersey in 1951 and 112 on the parallel highway (routes 1 and 130). For the American highway system as a whole in 1951 the equivalent rate was about 270. There were thirty-three fatal acidents on the turnpike in 1952, resulting in death to forty-seven persons, equalling a rate of 6·1 per 100 million miles, which compared with 7·7 per 100 million miles on all of the national highways.

The extraordinarily large volumes of traffic using the turnpike in 1952 emphasised the need for certain expansion to provide immediately and adequately for the still greater traffic in the years ahead. The current plans contemplate, subject to the completion of satisfactory financial arrangements, an expansion in the present turnpike to a six-lane highway from its present northerly terminus, adjacent to the George Washington Bridge, to interchange No. 4 serving the Camden-Philadelphia area. This is a distance of 83·3 miles, 22 miles of which already are six lanes. Of the three extensions of the turnpike which have been under review for some time, two have reached the stage of planning and design so that construction can be undertaken immediately upon the conclusion of financing. The first is a direct connection to the Pennsylvania Turnpike, requiring a new interchange south of the present Bordentown interchange, and participation with the Pennsylvania Turnpike commission in the cost of a new bridge across the Delaware River. The Pennsylvania commission is currently engaged in building an eastern extension from King of Prussia to the Delaware River for this direct connection. On the New Jersey side only 5 miles of new road must be built by the New Jersey Turnpike Authority and this can be constructed easily before the new bridge is completed. The first year's operation of this proposed connection is expected to add about 2,500,000 dollars to the Authority's gross revenues, of which an estimated 68 per cent will represent additional tolls collected on the present highway. The second project involves an extension of the turnpike from its Newark

Airport interchange easterly across a new bridge crossing Newark Bay, a limited access highway to the Hudson County peninsula and a direct connection to the Holland Tunnel. The consulting engineers indicate that tolls on this extension alone can amortise the investment in twenty-three years even without considering any benefit to the turnpike as now in operation. The third of the currently planned extensions is from the present northerly terminus of the turnpike at Ridgefield Park through Bergen County about 20 miles to connect with a spur from the New York State Thruway. This extension is still in the discussion stage and the Authority has not yet had final reports dealing with alignment or projected traffic and revenue. Its construction will depend upon final conferences with the New Jersey Highway Authority to determine whether or not the Garden State Parkway or the turnpike will best serve to solve vehicular traffic problems in this particular area.

A new scheme which has been under review for some months is the East-West Turnpike. This highway would be about 58 miles in length and it is thought likely that it would start at a point in Hudson County where it would serve a projected new trans-Hudson tunnel of the Port of New York Authority and proceed generally westerly, connecting with the present turnpike at a point between the bridge crossings of the Hackensack and Passaic Rivers. Then it would proceed generally through Kearny, crossing the Passaic River to the northerly part of Newark, and through the municipalities of Essex County, then through Morris County, the southerly tip of Sussex County, and on through Warren County to the Delaware River, where it would connect with two new bridges being built across the Delaware to Pennsylvania by the Delaware River Joint Toll Bridge Commission. Besides serving the densely populated and highly industrialised Essex County area in a manner heretofore not possible, this new highway also would open to further growth and development the northwestern area of New Jersey by providing an express highway to and from the metropolitan areas of northern New Jersey and New York.

The Wagon Wheel Gap Dam in Colorado

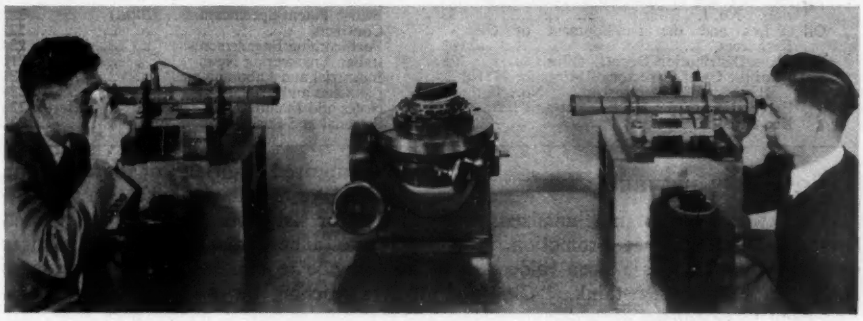
A report by the U.S. Bureau of Reclamation recommending the construction of the Wagon Wheel Gap dam in south-central Colorado, has been sent to other Federal agencies and the governors of Colorado, New Mexico and Texas for review and comment. The concrete dam, which will be 430ft high, is the key water control structure in the Rio Grande division of the San Luis Valley reclamation project. It would create a reservoir storage space for 1,050,000 acre-feet of water to regulate the flow of the Rio Grande River to furnish supplemental irrigation water for 271,000 acres of presently irrigated land in the San Luis Valley, generate 106,000,000kWh of hydroelectric power annually for southern Colorado and northern New Mexico, and provide flood control protection for areas in the two states. The creation of the Wagon Wheel Gap reservoir would provide irrigation farmers in the Rio Grande Division with a regulated annual divertible supply of water which would permit them to utilise more fully and beneficially the water available to Colorado under the terms of the Rio Grande compact, and thus permit a greater and more intensive land use. Moreover, additional storage and power production facilities are required to permit the development of hydro-electric power and to regulate flows which presently damage certain lands and cause other extensive flood damages in both the San Luis Valley and downstream areas. The dam has been planned to have a 50MW capacity power station, a 1000 acre-foot afterbay 5 miles downstream and the necessary transmission lines to interconnect the power system with other power systems near Alamosa and Salida, Colorado and near Taos, New Mexico.

A Basic Standard of Angular Measurement

A twenty-four-sided polygon of exceptional accuracy was recently constructed at the National Bureau of Standards, Washington, D.C., to serve as a basic standard of angular measurement. Made of precisely machined and polished gauge blocks accurately positioned at measured angular intervals on a circular baseplate, this polygon permits the comparison of an unknown angle with consecutive angular intervals until the total of such intervals equals an integral number of perfect 360 deg. angles. The polygon was designed primarily for use in the calibration of the 15 deg., 30 deg. and 45 deg. angle blocks of the master sets which are used in industry to control the shape—and hence the interchangeability and proper functioning—of mechanical parts produced by mass production methods. However, the principle of the device is expected to find considerable application also in the routine angular measurement work of the optical and mechanical industries.

Solid angular standards, or angle blocks, were developed at the N.B.S. during the last war as a result of the shortage of precise angular dividing equipment. They are hardened, ground and lapped steel blocks about 3in long, having specified angles between the two contact surfaces. Like gauge blocks, they may be combined with little error by wringing to form the sum or difference of a pair ; thus, a series of sixteen blocks can be mounted with a solid square to give any single subdivision of a circle to the nearest second. The accuracy of the angle blocks used in the United States is maintained by the Bureau, which calibrates the master angle blocks with which manufacturers compare their working standards. In general, the angular values of a set of master angle blocks can be determined, using interferometric methods of comparison, without reference to an external standard, but the necessary accuracy is difficult to obtain for the larger angles. The N.B.S., therefore, undertook to produce an angular standard that would permit the direct calibration of 30 deg. and 45 deg. blocks. The twenty-four sided polygon which was constructed has 15 deg. angles between adjacent faces and thus can be used to calibrate any multiple of this angle. The calibration of an angle block by means of the polygon consists of comparing the angle block with one or more angular intervals of the polygon. Angles are measured by sighting an autocollimator on the two faces which define an angle, then determining the angular difference between the two faces which define an angle and then determining the angular difference between the two settings. Each polished face acts as a plane mirror and a sharp image of the autocollimator cross hairs is formed. In practice, any error present in the calibration of the polygon is eliminated by comparing the angle block with a sufficient number of consecutive intervals to include an integral number of polygon rotations or circuits, i.e. an integral number of perfect 360 deg. angles. In this way it has been possible to determine the angles of master blocks with errors of approximately 0·1 sec.

The mechanical requirements for a standard polygon of the requisite accuracy for this kind of work have been found to be quite rigorous. The defining surfaces must be flat to one or two millionths of an inch over practically their entire area, the surface roughness of the faces must average less than 0·5 micro-inch, and the variations in the angle between the defining faces and the axis of the polygon must not be greater than 15 sec. As the construction of a solid polygon from a single piece of material to such limits would have been extremely difficult, it was decided to assemble the polygon by fastening gauge blocks, which were already available with satisfactory defining faces, to a circular base plate in such a way that their outer faces would form the standard polygon. To keep the diameter of the plate within reasonable limits the gauge blocks were placed in two layers of twelve each. The circular base of the polygon is 0·75in thick and 8in in diameter. It was made of oil-hardened steel and was heat-treated to obtain maximum dimensional stability. After hardening, the base was ground on both sides and then hand-lapped until the error in parallelism of the two surfaces was less than 0·0001in and the maximum error in flatness of each surface was less than 0·00006in. A rather high finish was imparted to one surface in the final lapping to permit wringing the special gauge blocks in position.



Calibration of 45 Deg. Angle Block Using Standard Twenty-four-Sided Polygon

Modified 0·750in rectangular gauge blocks were used for the defining faces. Their four lapped sides were plane to less than 0·000005in and their adjacent sides were square to within 2 sec. The surface roughness of each of the sides was less than 1 micro-inch r.m.s. This value was reduced still further by final polishing with a cloth lap. The nominal 0·375in thickness of the twenty-four blocks in the group varied less than 0·00003in. The bottom layer of blocks was selected so that adjacent blocks did not differ in thickness by more than 0·00001in. This procedure permitted at least a partial wringing of the blocks in the upper layer to those in the lower layer and reduced any distortion arising from the pressure of the clamping screws. Twenty-four tapped holes in the base plate permitted the use of the same screws for fastening both the upper and lower layers of gauge blocks. The holes were countersunk and then counterbored to a depth of $\frac{1}{4}$in to minimise the distortion of the base caused by the tension due to the tightening of the clamping screws. The positioning of the gauge blocks on the base plate was carried out on a carefully adjusted rotary table with the aid of 15 deg., 30 deg. and 45 deg. angle blocks, a solid square, and an autocollimator. The 0 deg., 90 deg., 180 deg. and 270 deg. faces were positioned by means of the square, and the intermediate faces by adding or subtracting 15 deg., 30 deg. and 45 deg. from these positions.

Two autocollimators and a rotary table were used in calibrating the polygon. The polygon was mounted on the rotary table and each autocollimator was placed on a substantial iron base with its optical axis in line with the junction of the upper and lower layers of blocks. To prevent dimensional changes in the surface plate owing to the body heat of the observers, the entire apparatus, except for parts of the autocollimators, was enclosed in an insulated box. Each autocollimator was centred on the appropriate polygon face by viewing the image of the cross hairs with a low-power microscope. After recording the readings of the two autocollimators for one angular interval the rotary table on which the polygon was mounted was then turned to present the faces of the adjacent angular interval. This process was repeated until every interval of the same nominal size had been measured and the circuit closed.

THE ENGINEER

Vol. 196 AUGUST 14, 1953 No. 5090

LEADING ARTICLES—

Employing Retired Engineers ... 208
Aircraft Noise and Its Remedy ... 208

ARTICLES—

"Avon" Turbo-Jet Engine Development ... 220
Biscuit Oven for Brazil. (Illus.) ... 205
Boats for the Royal Yacht ... 220
Chemical Engineering Conference ... 220
Diesel Locomotive Erecting Shop. (Illus.) ... 216
Elderly Engineer ... 198
Export of Aviation Equipment ... 193
Fourth International Astronautical Congress ... 203
Geared Inclinable Press. (Illus.) ... 206
Great Northern Railway (Ireland) ... 193
High Efficiency Air Cleaning Process. (Illus.) ... 211
Manufacture and Inspection of Aerofoil Models. (Illus.) ... 202
Moments of Area of Irregular Plane Figures. (Illus.) ... 213
Nuclear Reactors for Electric Power Generation. No. I. (Illus.) ... 176
Oil Prices and the Development of Oil Resources ... 193
Petroleum Distribution Depot. (Illus.) ... 205
Report of the Chief Inspector of Mines for 1951 193
Short History of Spectroscopy. No. II: Exploration of the Ultra-Violet and Infra-Red Regions. (Illus.) ... 194
Solution of Transient Heat Flow Problems by Analogous Electrical Networks. No. I. (Illus.) ... 217
Third International Conference on Soil Mechanics ... 193
Transfer of the Royal Observatory ... 193
Ultrasonic Inspection of Welded Pressure Vessels. (Illus.) ... 199
Unloading Dock for River Barges ... 216
120cm Naval Searchlight. (Illus.) ... 206

LETTERS TO THE EDITOR—

Room Temperature Ductility of Chromium ... 210
"Britannia" Locomotives ... 210
Influence of Fuel Gas on the Spraying of Metal Powders ... 210
Regime Flow in a Silt Carrying Channel ... 211

LITERATURE ... 209
Books Received ... 211

NEWS AND NOTES—

American Engineering News. (Illus.) ... 206
British Patent Specifications. (Illus.) ... 223
Contracts ... 222
Forthcoming Engagements ... 224
Indian Engineering News ... 219
Industrial and Labour Notes ... 221
Launches and Trial Trips ... 224
Notes and Memoranda ... 222
Personal and Business ... 222

EMPLOYING RETIRED ENGINEERS

When, with sadness (not unmixed with inward satisfaction that promotion is in sight) younger men see men older than themselves retire, they think, "Oh, blest retirement! Friend to life's decline. How blest is he who crowns, in shades like these, a youth of labour with an age of ease!" But nowadays, very often, Goldsmith's charming picture of serene old age amounts to so much poppycock. There is only too frequently no blessing upon retirement. For the professional engineer who retires to-day at an age of sixty or sixty-five is still physically and mentally active and no more suited to spend his declining years in idle and idyllic peace than men ten or twenty years his junior. Nor, in general, could he afford to do so even should he wish to. For pensions calculated to provide a comfortable standard of idleness in pre-war periods certainly provide nothing of the sort to-day. Unless, therefore, he is unusually lucky in the possession of private means he must either, in the words of a contributor to this issue, "vegetate, and ultimately die of frustration, ennui or premature senile decay," or, if he can, find some interesting job that will supplement his pension and make his age "as a lusty winter, frosty but kindly." Only too many we fear suffer the former fate.

Our contributor, Mr. C. E. R. Sams, who is well-known to all Old Centralians and to very many others besides, has made a particular study of this problem and has not been without encouraging success in finding suitable work for retired engineers who have appealed to him for help. He accepts without demur that men must retire when the retirement age of sixty to sixty-five is reached. For even though they may still be in possession of all their mental and physical faculties and far from yet "fallen into the sear, the yellow leaf," were they not to retire the promotion scale would be obstructed. That is, perhaps, a point open for discussion. For medical science in the last hundred years has so extended man's expectation of life and so much improved the health of those in more advanced years that retirement at the age of sixty or sixty-five may soon be regarded as quite unnecessarily early and younger men may be required to wait a little longer before reaching the vacated position. But that is a digression. Many a man of seventy to-day as much needs a job to keep him happily occupied and to supplement his pension as others more recently retired at sixty or sixty-five. But the jobs those older men want are not similar to those they did before retirement. They are conscious that they have somewhat less resilience and less vigour than of yore and that as they grow older they will have still less. They do not want to be tied to office hours; but they do want to be able to choose how much work to do and how much leisure to take. In the sense of filling a "vacancy" they are, thus, unemployable. But because they cannot fill a "vacancy" they need not go unemployed. As Mr. Sams points out they can still fill a "void"; and he defines a "void" as "a position that has not up to now been recognised, or thought of, or generally adopted," and claims that there are "about twenty suitable occupations and means of making use of the man's forty years' experience." He gives a number of examples.

Basically there is, in reality, nothing very new in Mr. Sams's idea. For, long since, many firms have made arrangements for the partial employment of retired men. In the technical Press, for example, retired editors and assistant editors almost invariably, we think, continue to contribute matter to the journals they served, financial arrangements varying elastically to accord with the particular circumstances. Engineering firms often retain retired senior executives in a "consultant" capacity or to do some useful but not essential job that would not otherwise get done. Skilled hands are sometimes similarly employed. We once remember meeting, for example, a workman far over seventy who made models of the firm's newer products, working as long or as short a time each day as he thought fit—and very fine models they were! What is more novel in Mr. Sams's suggestion is that firms should be invited not only to offer suitable work to their own retired employees but also to other retired men. Like Mr. Sams, we believe that there are plenty of jobs available which would never get done at all were retired men not available to do them. They would never get done because they are part-time and incapable of being reduced to a routine; because they require a responsible, experienced man to perform them yet cannot carry a large salary; and because they cannot effectively be done by anyone who is primarily employed for some other purpose. Again, there are other jobs where it is a positive advantage that the man doing them shall not be on anybody's staff but shall work in a free-lance capacity answerable only to the directors. For a man in that situation, particularly one of ripe experience, has an advantage similar to that of a civilian in wartime who can argue a point with all ranks from a private to a field-marshal, a thing he could not do were he in uniform. Yet once more, every firm at times finds that there is some responsible, but temporary, job to be done that does not fall at all easily either within the ordinary routine or within any department's particular care. There is then a strong case for finding a retired engineer to take it on. The normal attitude of employers towards jobs is one of observing that there is a job to be done and finding a man capable of doing it. But there is an alternative approach. It is to observe that here is a man who can do a certain kind of job and to fit the job to the man. If directors were to think upon those lines we believe, with Mr. Sams, they would find that retired engineers could perform many valuable services, services that only they could adequately perform and services that are not at present performed merely because few people have thought of fitting the job to the man instead of the man to the job. A managing director might well say in recommending the employment of one of them "His silver hairs will purchase us a good opinion and buy men's voices to commend our deeds."

AIRCRAFT NOISE AND ITS REMEDY

The noise caused by aircraft has grown to be a real nuisance and threatens to become worse. A remedy is needed and the sooner the better lest the development of an important industry be gravely hindered. The nuisance comes from both civil and military types; of the two the military tends to be the worse offender, though fortunately its offence is less likely to occur in the neighbourhood of large cities. Civil aircraft naturally concentrate near the centres that supply the air passengers who in increasing degree make use of this quick means of transport. Fortunately, these civil aeroplanes have a lower power rating and so are less noisy; and this state of affairs seems likely to persist since civil airports, having usually to be located well outside built-up areas, take so long a time to reach by airline buses that it is hardly worth while to raise the air speed of airliners beyond a point. Experience of travel between London and Switzerland, for instance, by the new excellent "Viscount" service of the B.E.A. shows almost as much time to be taken on the road as in the air; so that even if the

air speed were doubled the time saved would be but fractional.

In the early days of flying the noise trouble was mainly that inflicted on passengers, and was due in almost equal degree to aerodynamic turbulence and engine exhaust; but with improved designs of both airframes and engines—and, in later days, pressurised cabins and turbine engines—the passengers have little to complain about. The chief nuisance now is to those who live near busy airfields or below important airways, and it is for their sake that action has become so necessary. A considerable ingredient in the make-up of airport noise arises from the normal engine performance tests after necessary servicing. But as we mentioned in a recent issue (July 17th), an experimental "acoustic wall" has been built at London Airport with the object of screening the engine noise from the nearest built-up area; this long, curved brick wall with its noise-absorbing qualities is some 30ft in height; we certainly wish the ingenious experiment every success. Military aircraft are bound to be less easy to deal with. Their high air speed necessarily makes them noisy, but that very speediness they must have in order to act as a defence against any and every form of air invasion from across the seas. All that can be done, therefore, besides making regulations controlling the height of flying, is to place the airfields in as sparsely inhabited areas as are available and yet so located as to be strategically and tactically appropriate for the purposes for which they exist. Already there are in service military aircraft, piloted or pilotless, having speeds up to and even beyond the sonic (i.e. 750 m.p.h. at sea level and 650 m.p.h. in the stratosphere), and when such speeds are reached the noise is immensely increased; indeed, if one accepts an estimate put forward at the recent Joint Symposium of the Royal Aeronautical Society, with the Acoustics Group of the Physical Society, an important component of the noise may rise as fast as the eighth power of the speed! This, if true, is indeed alarming; and at the sonic boundary the sound can reach the hearer's ear in the form of a sudden and intense bang, so severe if close at hand as to be powerful enough to break windows, damage roofs, and, what is worse, hurt the human ear-drum. Much has been written to explain why this happens when it does, and it is plainly a highly complex phenomenon; for the aircraft when at the sonic barrier may be accelerating, or decelerating, or changing course rapidly and the aggregate effect be hard to disentangle. What often happens in practice is a succession of intense bangs at odd intervals—an unpleasant and even dangerous experience.

Although there is not known at present any simple and practical way in which the modern jet engines can be made substantially less noisy, Mr. Greatrex, of Rolls-Royce, was able to suggest at the Joint Symposium already mentioned that there was hope of producing such a shape of jet nozzle as would lead to a noise reduction of as much as 8 to 10 decibels though he admitted that the reason for such a welcome improvement was not yet understood. Another and more fundamental remedy put recently before the Royal Aeronautical Society came from Professor Richards, as a result of studies made at the University of Southampton; this was that designers of civil aircraft should be ready to accept a substantial reduction in the turbine jet velocity even at the cost of a corresponding increase in the mass flow and a certain weight penalty; this, he predicted, would provide a handsome dividend in excess of anything to be expected from noise suppression devices. Further research on lines such as these is certainly very necessary. The helicopter has not so far been looked on as equally troublesome. Perhaps there are not enough of them yet to form a real nuisance, though what degree of unpleasantness the future may have in store has yet to be heard. One press writer has, however, typically, described the flying of a small helicopter which was fitted at the blade tips with ramjet engines, "as making a noise like the Day of Judgment." However this may be, no subject presses more for technical investigation than that of the way in which the whole mass of aircraft noise can somehow be abated and the nuisance lessened.

Literature

Studies in Elastic Structures. By Professor A. J. S. PIPPARD. London: Edward Arnold and Co., 41, Maddox Street, W.1. Price 60s.

HERE, in a well-produced volume of some 360 pages, are brought together various studies made by Professor Pippard and his colleagues in thirty fruitful years: of stresses in circular and in polygonal rings (including the frames of rigid airships), in wheels, bridge girders, open-panel and lattice frames; of arches, both in masonry and in metal; of cables and of pipelines. The leitmotiv which gives the volume continuity is a doctrine akin to Saint-Venant's famous principle: that resultant actions, rather than the precise modes of their application, are what in the main determine elastic stresses; consequently the engineer (whose problems do not call for mathematical exactitude) can, at will, replace concentrated by distributed forces, discrete by continuous restraints, or vice versa, as may best suit his convenience. Otherwise the twelve chapters are largely independent, each treating a problem that was presented separately—as problems are to an engineer in practice. This is not a textbook aiming to illustrate principles; its purpose is to solve particular problems and to give the results in a way that makes them practically useful.

For what class of reader, then, does the volume cater? Hardly for the undergraduate student, it would seem, except as a book for reference when he comes to study one of the problems which it treats; nor for the practising engineer, unless and until he confronts one in his work. But the teacher concerned to illustrate general principles will find here a mine of suitable examples; and a graduate student busy with his first thesis will find here models of clear and adequate exposition. That is a task that badly needed doing, for it is a commonplace that the presentation is deplorable of much work done in the technical field; and the book is a model in another respect—its generous ascriptions of priority and credit.

Not only are its problems treated analytically; most chapters include accounts of careful experiments made in order to check the theoretical results. The closeness of the verification, normally, is all that could be desired—in fact, in one place it is described as "unexpected." But perhaps it is permissible to question whether it was worth while to reproduce so carefully (in some instances) the simplifying assumptions of the theory. Is not the function of experiment, rather, to find what errors those assumptions entail? To take a single example:—Frameworks, whose members, in fact, are connected rigidly are commonly treated under the defensible assumption that the influence of joint-rigidity is negligible; such treatment must entail some error, and only experiment can decide its magnitude. Would not more be learned, then, by testing a model of the actual frame than by testing one whose joints have carefully been rendered "free"? Is it not as good as certain (if the usual checks have been applied) that computation must be supported by experiments in which its assumptions are exactly reproduced?

Plainly, this is a general and a philosophical question—perhaps not properly raised in a review. But it is a question that seems to call for discussion, somewhere, as fundamental to the philosophy of engineering science. Outside of teaching (where they can help to comprehension of a theory), what is the role of experiments in science pursued *with a view to application*? By definition, not that of "tests" in engineering practice; and seldom, presumably, a means to new discovery—as in the "purer" physical sciences? What are the complementary roles of experiment and theory, in a discipline where most problems are *particular*? The question matters; for on its answer depend (or should depend) our plans for "extension of higher technological education."

Foundation Engineering. By R. B. PECK, W. E. HANSON and T. H. THORNBURN. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 54s.

THIS book deals with the founding of buildings and engineering works upon all sorts of ground. The basis of the book is the new science of soil mechanics, and one of the authors of the book, Ralph B. Peck, is already well known as having been associated with Karl Terzaghi in the publication of authoritative works on the subject of soil mechanics. These earlier publications dealt more particularly with the theoretical side and concentrated upon getting the recent knowledge that has been acquired by laboratory experiment crystallised in the form of mathematical formulæ, a procedure which contrasted sharply with the traditional method hitherto used by generations of engineers whereby nearly all these foundation problems were settled (and for the most part quite adequately and economically settled) by rule of thumb aided by experience and good judgment. The present work, by giving prominence to the practical problems and especially by frankly admitting the existence of imponderable factors, comes within measurable distance of reconciling the two viewpoints and may, therefore, be regarded as making a welcome contribution to the state of the art. From the point of view of the engineering student, the book, in spite of its irritatingly pedantic use of decimal point notation in the numbering of diagrams and paragraphs, has two distinct merits, first, that it presents the subject in an interesting way and, secondly, that it does not demand a too incessant use of mathematics.

Considered as a work of reference for the use of practising civil engineers, the book

is of some value and originality. In reaching this conclusion, the reviewer, who happens to be a practising engineer, has applied the acid test of bringing one or two of his own current problems into contact with corresponding paragraphs in the book. One of these actual problems relates to the design of a graving dock. Bores show that the proposed structure will rest upon and be almost wholly bedded down within a stratum of hard boulder clay of glacial origin. Soil mechanics tests made upon this clay indicate properties which merely corroborate what any experienced engineer already knows, and while useful, cannot be regarded as throwing any fresh light. There has, however, been disclosed in one part of the site, the existence of a lens of water-bearing sand sandwiched between layers of boulder clay, a disconcerting circumstance which on account of pore water pressure is bound to affect the design quite considerably. On referring to the book it was found that pages 118, 119 and 120 dealt from the geological standpoint with the origin of just such pockets of glacial outwash in boulder clay and a perusal of these pages does, in fact, give the reader a very good idea as to what to look out for in such conditions.

Another of the reviewer's current problems has to do with the establishment of very deep pile foundations to support bridge piers in the alluvial bed of an eastern river which is subject to severe annual floods caused by melting snow. In this connection page 183 of the volume under review contains some remarks of an enlightening character which, while agreeing very well with the reviewer's own opinion and experience, are such as are not usually to be met with in text books. One of these observations is to the effect that "both experience and theory have demonstrated that there is no danger that a point bearing pile may buckle on account of inadequate lateral support, provided it is surrounded by even the very softest soils."

Another acute observation at the bottom of the same page refers to a pile's "ability to penetrate deeply enough to reach the bearing stratum." It goes on to say that it is largely a question of "the capacity of the pile to transmit the energy of the hammer from the butt to the point" and that this capacity in turn "depends primarily upon the material of which the pile is made," steel being afterwards mentioned as the best material for transmitting the energy.

It is creditable, therefore, to the book to find that its geological section throws useful light upon the graving dock problem and that the principles just quoted are such when properly applied as lead to the most economical design solution in the case of the deep bridge foundations.

The portraits of engineering worthies, one of which heads each chapter, constitute an unusual addition to a book of this character. Not only are the portraits inartistic and badly reproduced, but the sandwiching of a few eminent Europeans of a former age among a number of comparatively undistinguished Americans of the present epoch, however gratifying it may be to some of the latter, is, in a book intended for international circulation, an error in poor taste.

FACTORY EQUIPMENT EXHIBITION, 1953.—It is announced that the second National Factory Equipment Exhibition will be held at the Royal Horticultural Society's Halls, Westminster, from March 22, to March 26, 1954. The exhibition will be sponsored by *The Factory Manager* and *Factory Equipment News*, and organised by Mr. J. E. Holdsworth, 117, Kingsway, London, W.C.2.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

ROOM TEMPERATURE DUCTILITY OF CHROMIUM

SIR,—In the issue of THE ENGINEER of May 1, 1953, a short review of the above subject, summarising a progress report of current work at the Battelle Memorial Institute[1] appeared on page 632 under the title "Is Chromium Inherently Brittle?" The work mentioned has shown that small chromium crystals produced by the iodide process can be reduced in thickness by 35 to 40 per cent by slow compression at room temperature; but that rolled strip produced from arc-melted "iodide" chromium

Deformation Markings on Ductile Chromium

failed in a completely brittle manner when tested in bending or in tension at a rate of straining of 0·001in per minute.

The problem of the room temperature brittleness of chromium is under investigation at the Aeronautical Research Laboratories, Australia, and some of the results obtained have already been published.[2,3] In brief, it has been found that small arc-melted ingots of electrolytic chromium can be forged, swaged and rolled in the temperature range 600–900 deg. Cent. provided the chromium is protected from the atmosphere at all stages by enclosing in stainless steel and/or mild steel sheaths. Strip produced in this way has a cold worked structure, a Vickers hardness in the range 170–270, and is normally brittle as removed from the sheath. However, it is found that the strips can be bent plastically at room temperature provided the outer impure layers are first removed by acid etching and further work has indicated that nitrogen and/or oxygen may be the embrittling impurities.

The extent of the room temperature ductility achieved to date is such that specimens of the order of 0·040in thick can be rapidly bent through 90 deg. and sometimes through 180 deg. and back again, without fracturing. Also a preliminary tensile test has been made at room temperature and at normal rates of loading on a small specimen (2in by 0·25in by 0·03in) cut from rolled strip. This specimen had a yield stress of 51,500 lb per square inch and deformed almost 3 per cent, at least 2 per cent plastically, before failure occurred at a stress of 61,500 lb per square inch, through a loading pin-hole—due to faulty design of the specimen. Typical "orange peel" deformation markings produced on the specimen surface can be seen in the figure.

These results show that the query posed by your article can definitely be answered in the negative. Chromium showing some considerable degree of ductility at room temperature, can be produced in comparatively massive form by conventional working methods provided certain precautions are observed and there seems to be no reason, at least in principle, why this should not become a commercially feasible operation. Also the work indicates that the use of similar techniques may ultimately lead to the production of ductile chromium-rich alloys on a commercial scale. This fact is of considerable technological importance since some of these materials are known to have outstanding potentialities for high temperature applications.

L. P. COOMBES,
Chief Superintendent,
Aeronautical Research Laboratories,
Fishermen's Bend, Australia.
July 29th.

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[1] Goodwin, H. B., Gilbert, R. A., Schwartz, C. M., and Greenidge, C. T., *Journ. Electrochem. Soc.*, 100 (4), 152 (1953).
[2] Henderson, F., and Wain, H. L., Department of Supply, A.R.L. Report SM.202, March, 1953.
[3] Wain, H. L., and Henderson, F., *Proc. Phys. Soc.*, B, 66, 515 (1953).

THE "BRITANNIA" LOCOMOTIVES

SIR,—It is extraordinary to what heights of verbal indiscretion steam locomotive partisanship can rouse people. From his letter in your issue of August 7th one can assume that Mr. Gwyer disapproves of the "Britannia" locomotives, and his disapproval has lured him into sticky ground. I should imagine that he read my articles and wrote his letter to you, Sir, while under the stress of deep emotion; otherwise he would certainly have checked up on the present locomotive position in East Anglia before writing his last sentence!

Then he states: "Mr. Nock hails the advent of the large boiler as if it was a remarkable new invention." I do not know where he found this piece of acclamation on my part. He may be referring to the passage in the article in your issue of July 24th, where I quoted from the bulletin two sets of circumstances in which the large boiler is stated to have an advantage. But there I neither disagreed nor endorsed the views officially expressed.

O. S. NOCK

Bath, August 8th.

THE INFLUENCE OF FUEL GAS ON THE SPRAYING OF METAL POWDERS

SIR,—I read with interest the article under the above title in your issue of July 3rd, and in particular I would refer to Table III on page 7, which gives values of flame velocity in centimetres per second and per cent gas in air. The article states that the figure in Table III is a compilation of those taken from various authorities for the rate of flame propagation, and whereas this table covers hydrogen, acetylene, propane, butane and methane, it does not offer any figures for the flame velocity of ordinary coal gas. Can you advise me of the equivalent figures for coal gas in air?

R. CESCOTTI

London, W.4, August 4th.

[Mr. McDermott, one of the authors of the article, replies:—"It is not possible to give Mr. Cescotti an accurate figure which he can compare with those listed in Table III of our paper, since, as far as we can ascertain, the flame velocity of coal gas has not been measured under conditions similar to those used to obtain the quoted figures. However, in *Fuels and Their Combustion*, by Haslam and Russell, pages 269–270, there is a record of observed flame velocities of coal gas in air, using a 1in diameter tube, and varying the quantity of coal gas between 7·5

and 25 per cent. The flame velocity ranges from 21 cm per second to 158 cm per second (maximum speed mixture corresponding to 17 per cent by volume of coal gas in air). Under the same conditions of test the flame velocity of hydrogen ranges from 21 cm per second to 485 cm per second (38·5 per cent hydrogen in air) and methane ranges from 21 cm per second to 67 cm per second (9·9 per cent volume of methane in air). On examining Table III it will be seen that the maximum figures quoted by Haslam and Russell can be transferred into our figures by multiplying by a factor of 0·55. Applying this factor to the maximum figure quoted above for coal gas (158 cm per second) reduces it to 87 cm per second, and I would say that it would be reasonable to utilise this figure for comparison purposes."—ED. THE E.]

REGIME FLOW IN A SILT CARRYING CHANNEL

SIR,—With reference to the article on "Regime Flow," contained in your issue of July 10, 1953, I think I should point out that the thirty-odd formulæ of Lacey all follow directly from two of his formulæ and hence are interlinked. What Mr. Cooke did was to work out the value of f in the S, Q, f formula and then apply the same value of f in the R, Q, f formula, and by multiplying the R value with the P value he obtained a value for A which was 2·2 per cent more than the measured area; but had he used Lacey's formula

$$A = 1 \cdot 26\, Q^{1/6}/f^{1/3}$$

he could have worked out a value of f which gave no error in A.

The question is what does this value of f mean, and could it have been worked out from the silt found in the canal?

Lacey at one time worked out a regime silt factor

$$f = 1 \cdot 76\, m^{1/2}$$

where m is the equivalent weighted mean diameter in millimetres; but later work has indicated that the "charge"—that is to say, the quantity of material in motion—has a marked effect on the slope and shape of stable channels in alluvium.*

I certainly do not wish to underrate the great value of the Lacey formulæ and can quote several cases where the values of f in the various Lacey formulæ varied even less than in the case quoted by Mr. Cooke; but unless f is linked with the sand of the bed and can be evaluated in advance, it can only be roughly predicted from previous experience of similar conditions. It would be helpful if Mr. Cooke could give information about the material exposed on the bed of the canal and similar data for other channels of the Gezira scheme.

SIR CLAUDE INGLIS, C.I.E., F.R.S.
Hydraulics Research Station, Berks.
August 4th.

Books Received

Corrosion. Vol. 5, 1952. London: Butterworth's Scientific Publications, Ltd., 88, Kingsway, W.C.2. Price 6s.

Permanent Magnets. Sheffield: Permanent Magnet Association, 301, Glossop Road, Sheffield, 10. Price 10s.

Circuit Breaking. By H. Trencham. Butterworth's Scientific Publications, Ltd., 88, Kingsway, W.C.2. Price 30s.

The Marseilles Block. By Le Corbusier. London: The Harvill Press, 23, Lower Belgrave Street, S.W.1. Price 21s.

British Standards Yearbook. London: British Standards Institution, 24, Victoria Street, S.W.1. Price 12s. 6d.

Copper and Brass Pressings. Publication No. 26. Radlett, Herts: Copper Development Association, Kendals Hall,

* Historical note on "Empirical Equations Developed by Engineers in India for Flow of Water and Sand in Alluvial Channels," Paper No. 5, presented at the second meeting of the International Association for Hydraulic Research, Stockholm, by the writer.

High Efficiency Air Cleaning Process

By I. M. DAVIDSON and D. R. WHITTET

A 50MW gas turbine set would aspirate some 500,000 cubic feet of air per minute. Cleaning such large quantities of air constitutes the problem here studied. It has been found that, when the anode of an electrostatic cleaner is moistened with water, carbon particles in the air no longer reverse the polarity of their charges, but are precipitated on first approaching that electrode. Two experimental cleaners are described and the results of tests are given and discussed.

WHEN an axial flow compressor is operated in the atmosphere of an industrial city its blades quickly become fouled with airborne matter and a considerable loss of efficiency thereby results. In a typical gas turbine station a loss of 1 per cent in the compressor efficiency would result in a reduction of about 1 per cent in the busbar efficiency and 3 per cent in the maximum station output, so it appears that such a process could not be tolerated in practice. Research on the problem was therefore undertaken at the National Gas Turbine Establishment and, in the early stages, solutions were sought along the lines of so designing a compressor that either it would not accumulate fouling on its blades or it would not suffer in performance when contaminated. However, as a result of those studies the possibility of such a solution seemed ever more remote and, in the end, faith could be pinned only on the last alternative of complete air filtration. Quite apart from its scale—a typical 50MW set would aspirate some 500,000 cubic feet per minute of air—such a process departs in three main respects from previous engineering requirements. First, the matter to be separated is substantially smoke in permanent suspension and so consists wholly of rather small particles, the mean size being around 1 micron. In composition about two-thirds

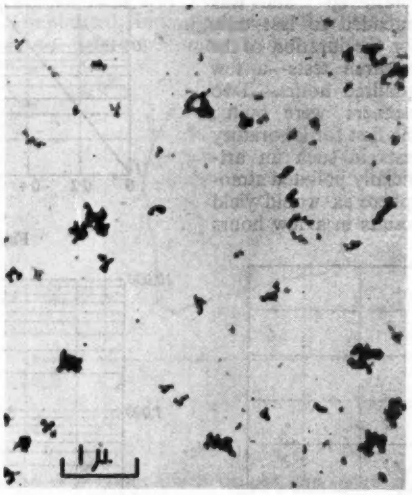


Fig. 1—Electron Micrograph of Individual Smoke Particles

of this material comprises free carbon, oils and tarlike substances, and its appearance is suggested by the typical electron-micrograph of Fig. 1. The second departure is in the concentration of the material which, foggy conditions excluded, might be about 0·3 milligramme per cubic metre (or 0·00013 grain per cubic foot). Finally, if the loss in busbar efficiency as a result of compressor blade fouling in a typical station is not to exceed 1 per cent per year, it is estimated that filter efficiencies of about 99·9 per cent or better must be guaranteed. In more significant terms, the concentration of particulate matter in the air must be reduced to about one two-millionth of that in the effluent from the recently described and presumably representative flue gas cleaning plant at Tir John power station, Swansea.*

Two further, but nevertheless essential, requirements were that, to prevent any possibility of a blow through, the filter must be continuously self cleaning in action and, for obvious reasons, it must be made and

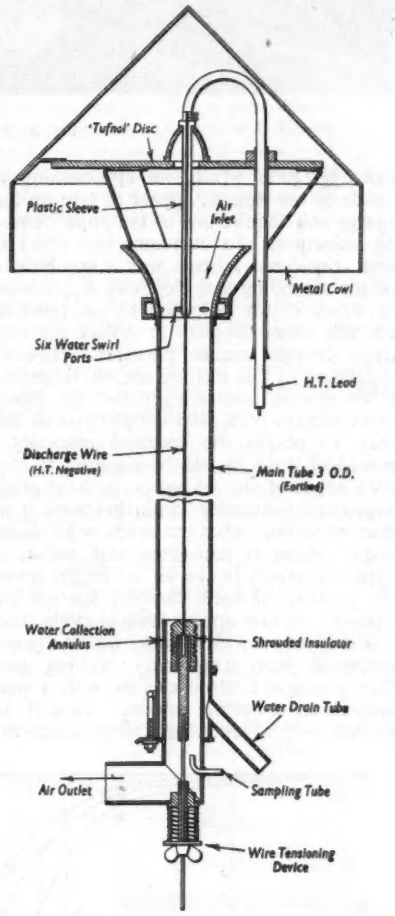


Fig. 2—General Arrangement of Experimental Cleaner

installed for only a small fraction of the cost of an orthodox "high" efficiency cleaner. From the start it was clear that no combination of commercially available systems would ever be satisfactory and a search was therefore made to isolate the most promising basic physical process. After studying the mechanisms of diffusion processes, thermal precipitation, ultrasonic flocculation, centrifugal and scrubbing processes, &c., it was concluded that the only feasible principle was that of electrostatic precipitation, but there were still many different ways in which this could be applied. The principal difficulty was that peculiar and notorious behaviour of carbon and other electropositive particles whereby they form chain-

* The Association of Consulting Engineers Selected Designs: Festival of Britain, 1951; Princes Press Ltd.

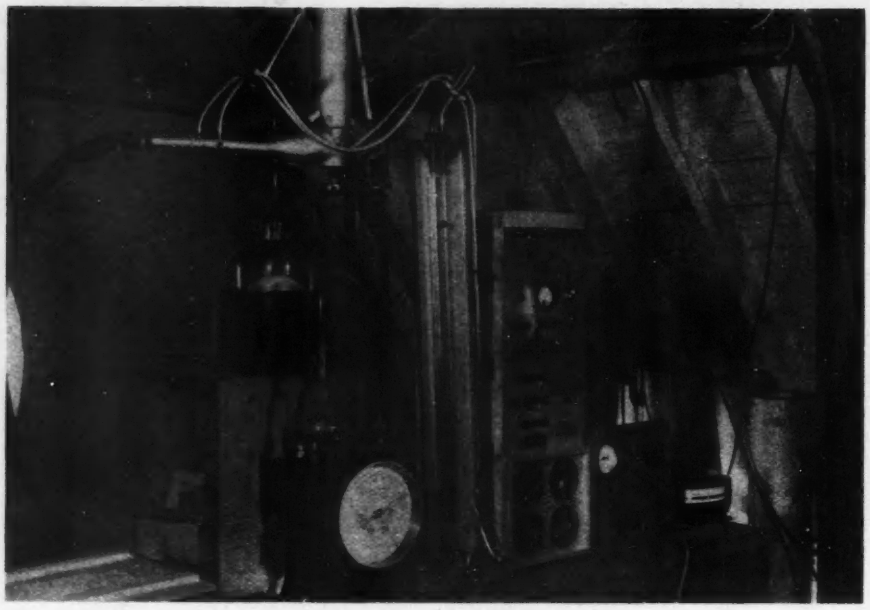


Fig. 3—The Greenwich Installation

like aggregates which, on approaching the anode of the cleaner, appear to give up their charge and acquire one of the opposite sense by induction. To overcome this effect the first considered scheme was a combination of the scrubbing and electrostatic processes, in which it was proposed to use positively charged water droplets to collect the negatively charged smoke particles. However, promising as this method seemed in general, a few months' research revealed the capture cross section of typical droplets to be such that, to obtain the specified efficiency, a pound of water would be required to clean each pound of air. However, in the course of experiments associated with that work it was discovered that, when the anode of an electrostatic cleaner is moistened with water, the carbon particles in the air no longer reverse the polarity of their charges, but are precipitated on first approaching that electrode.

The filter on which work was finally concentrated was accordingly nothing more than a simple Cottrell cleaner with a water film as its collecting anode. Since it was desired only to establish the existence of a general solution to the compressor blade fouling problem, no attempt was made to incorporate such practical details as the twisted square-sectioned cathode, tensioning by weights and the admission of the polluted air at the lower end, &c. Indeed, as is illustrated in Fig. 2, the cleaner was simply a temporary "lash up" and was intended to last only for the duration of the research tests—a few hundred hours. Two cleaners were built; the first for laboratory tests in such an artificially polluted atmosphere as would yield results in a few hours and the second for prolonged confirmatory tests in the field. For this purpose the model was installed in the roof of a building at the D.S.I.R. Fuel Research Station, Greenwich, where the photograph (Fig. 3) was taken. It was thought at first that there might be considerable difficulty in obtaining an unbroken water film on the wall of the earthed mild steel tube, but with six tangential swirl ports at the entry, a moderately degreased surface, and a little soapless detergent in the water at the start, there was found to be no difficulty. Indeed, ordinary tap water was then used throughout the tests. One interesting point was that, when in one of the earlier tests a dry patch did develop on the anode, a local deposit of soot built up on the cathode opposite. Thus it seems that the water electrode not only ensures the direct precipitation of carbon particles, but prevents them from forming troublesome deposits on the high-tension wire which remained clean throughout some 2000 hours of normal testing.

Both the cleaners were of 2·94in internal diameter and 98·5in long with a cathode which was normally of 16 S.W.G. copper wire, but in some of the later tests the laboratory model was run with a 22 S.W.G.

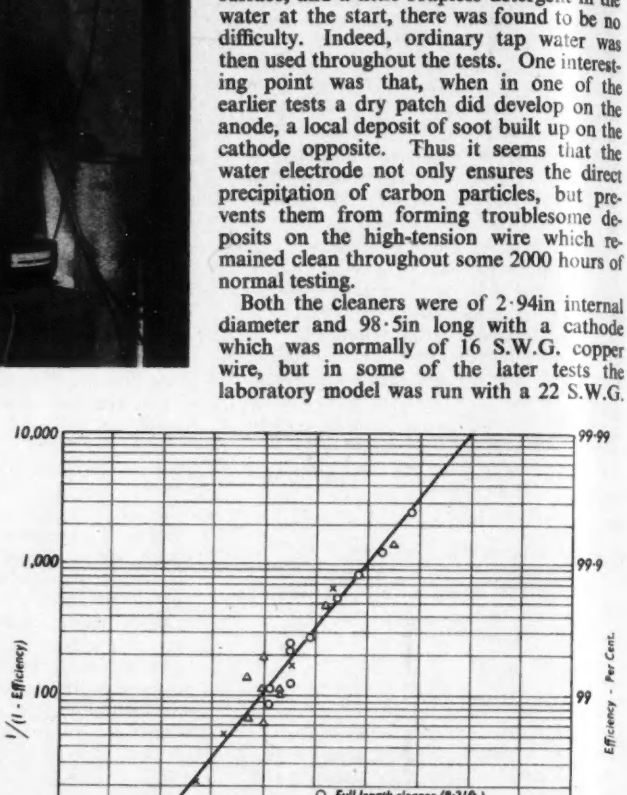


Fig. 5—The Significance of Transit Time

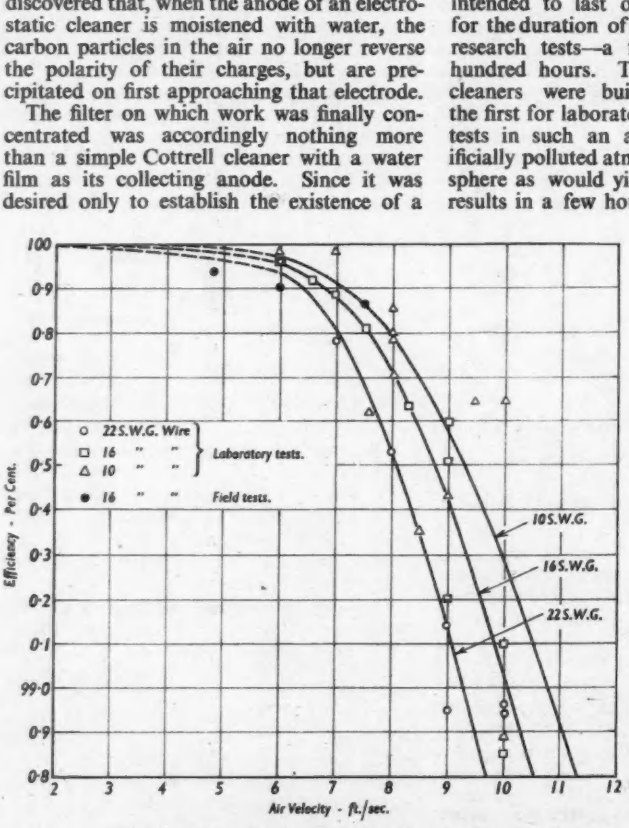


Fig. 4—Typical Results from Experimental Cleaner

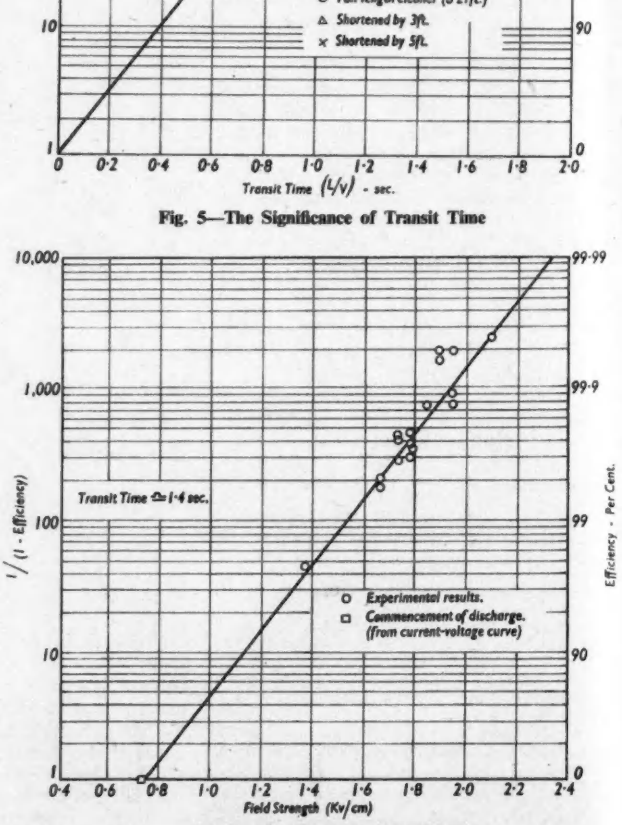


Fig. 6—The Effect of Field Strength

and then a 10 S.W.G. cathode, and was ultimately cropped in stages to a length of 38·5in. The efficiency was measured by the well-known blackness test method, in which a sample of the cleaned air was drawn through a high-resistance filter paper in order to produce a grey stain. For example, if the stain took 1500 minutes to form and, when the high-tension supply to the cathode was interrupted, a stain of precisely the same photometric shade was produced in 90 seconds, the efficiency by this method of reckoning was 99·9 per cent. It was proved by backing up the sampler with a thermal precipitator of which the slides were scrutinised microscopically, that no particles escaped the filter paper, but there still remained one further unknown—the relative intensity of pollution during the runs with and without high tension. In the laboratory uniformity was achieved by using as the source of pollution a smoky butane-air flame, which was formed in a sheltered region away from any surfaces which could acquire soot deposits and to which both the gas and air supplies were stabilised and carefully regulated. In the field each cleaning run lasted for hundreds of hours and the pollution was clearly beyond our control, but Greenwich was chosen for the experiments because, at the Fuel Research Station, a twenty-four-hour survey is made of the atmospheric pollution and a precise correction could therefore be applied to cover the natural variation in intensity.

The results of Fig. 4 are typical of those obtained throughout the tests and, whereas at first sight the agreement between the laboratory and field tests is not as good as might be expected, the efficiencies were of the same order in each case. Moreover, a critical examination of the instrumentation and testing procedure ultimately revealed that the actual efficiency of the cleaner at Greenwich must have been consistently higher than that recorded, so it thus appears that the laboratory test results can confidently be accepted as typical also of those likely to be achieved in practice. In turning to the effects on efficiency of the cleaner geometry, power consumption, and mass rate of flow, &c., there seem to be four significant variables—the tube diameter and length, the electrostatic field strength, and the air velocity. With the exception of a few tests on an 8in diameter cleaner which was so short as to be unreliable on account of secondary "end" effects, all the research was conducted on 3in tubes. Nevertheless, a careful study of the results plus those from some detailed electrical measurements made over a wide range of voltage in wire-in-tube systems up to 10in diameter suggested that, for any one field strength and air velocity the same efficiency should be obtained provided only that the length to diameter ratio of the tube is constant. Then, as is well illustrated by Fig. 5, the air velocity and tube length can be combined in the form of a single variable termed the transit time, so leaving for consideration only the strength of the electrostatic field. This, of course, varies radially in the tube in a manner which depends on such things as the cross sectional area and shape of the central wire electrode, and the most typical value is therefore not in any sense a mean, but is that estimated for the field in the vicinity of the tube wall; its exponential effect on the efficiency being illustrated in Fig. 6.

In this connection it will be observed that the efficiency can be regarded in practice in two ways. If one is trying to recover a valuable powder or "fume" it is simply the efficiency that matters and there is little point in striving to obtain values over, say, 95 per cent or 97 per cent. However, if the problem is to prevent the fouling of an axial compressor, the poisoning of a catalyst, or the contamination of a building, &c., the real criterion is that of Figs. 5 and 6, namely $(1-\text{efficiency})^{-1}$, and it is quite clear that the law of diminishing returns no longer applies. A further practical point is that in the ranges considered the blackness test efficiency of a cleaner will be lower by an unknown but appreciable amount than its gravimetric efficiency, and this should be borne in mind when comparisons are made with existing types of equipment. Lastly, throughout the work the cleaner power consumption was maintained at a very high level—about 700W per 1000 cubic feet per minute for an efficiency of 99·9 per cent. However, this was because the central electrode was for simplicity a tensioned wire, and there are several means which could be used in practice to reduce this consumption by a factor of, say, five or ten.

For permission to publish this article the authors must thank the Chief Scientist of the Ministry of Supply, and acknowledgments are due also to the director and staff of the D.S.I.R. Fuel Research Station for the provision of facilities for, and co-operation during, the field tests. The illustrations are "Crown Copyright Reserved" and are reproduced by permission of the Controller, H.M. Stationery Office.

Moments of Area of Irregular Plane Figures

By H. G. EDMUNDS, B.Sc., Ph.D., A.M.I.Mech.E.

In this article a graphical method is described of determining the moments of area of an irregular plane figure about arbitrarily chosen axes. The system depends upon the use of transparent overlays having grid lines, the appropriate scale and spacing of which is described. Limited applications of the method are well known, but it is developed in two directions: towards the determination of moments with respect to a pair of rectangular axes in the plane of the figure, and towards the determination of "polar" moments about an axis that is normal to the plane of the figure.

IT is often necessary to determine a moment of area of an irregular plane figure which is not amenable to formal integration. The "moment" may arise in many forms: in mechanics as a factor in moment of inertia, in structures as summations of the type $\Sigma M \,.\, x \,.\, dx$, or in strength of materials as the principal second moments of area of a section subjected to bending. Since the principal axes are not necessarily known in advance this last problem is rather more complicated, but in any case the first task is to determine some moment when the

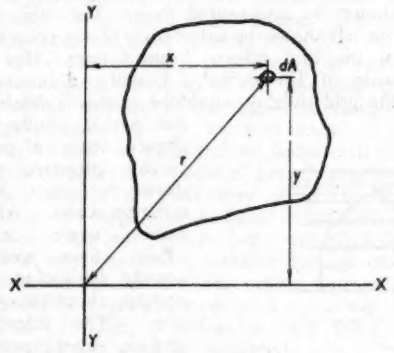


Fig. 1

axes are either given or else are arbitrarily assumed. There are many ways in which this may be done, but the most convenient, and perhaps the most accurate, involves the use of transparent overlays which are ruled with grids of appropriately spaced lines. Grids of this kind for determining second moments about a single axis which lies in the plane of the figure are in common use, but so far as is known a description of the method has not been published, and it is therefore not possible to make an acknowledgment of first authorship.

Moments About Axes in the Plane of the Figure

Fig. 1 illustrates an irregular plane figure which is defined with respect to a pair of rectangular axes XX and YY. The area of the figure is denoted by A, and an element of area, dA, is distant y from XX, and x from YY.

In general the $(p+q)$th product moment of the area with respect to the two given axes may be defined thus:

$$M_{XY} = \Sigma dA \,.\, y^p \,.\, x^q.$$

More particularly, however, a moment of the area with respect to either XX or YY alone may be defined. Thus, the pth moment about XX is:

$$M_{XX} = \Sigma dA \,.\, y^p.$$

or the qth moment about YY is:

$$M_{YY} = \Sigma dA \,.\, x^q.$$

The determination of a moment with respect to a single axis will be considered first.

Moments About a Single Axis in the Plane of the Figure

Referring to Fig. 2, consider moments of

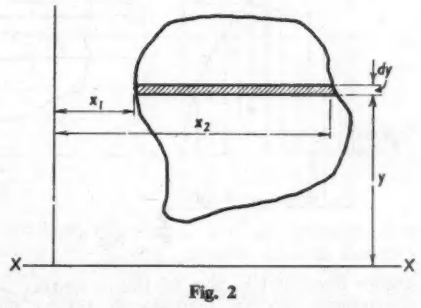


Fig. 2

the given area about the axis XX. The required moment is:

$$M_{XX} = \Sigma dA \,.\, y^p.$$

It is appropriate to consider a strip element of uniform depth dy, parallel to XX, and distant y from it.

Then:

$$dA = (x_2 - x_1)dy,$$

and

$$M_{XX} = \Sigma (x_2 - x_1) \,.\, y^p \,.\, dy.$$

But

$$y^p dy = d(y^{p+1})/(p+1).$$

Therefore

$$M_{XX} = \Sigma(x_2 - x_1) d(y^{p+1})/(p+1).$$

In order to evaluate this sum, the given area may be divided into a number of parallel strips the depths of which are so adjusted as to give the increments $d(y^{p+1})$ a value which is common to all strips.
Then :

$$M_{XX} = \frac{d(y^{p+1})}{p+1} \Sigma(x_2 - x_1),$$

and for strips of finite depth, δy :

$$M_{XX} = \frac{\delta(y^{p+1})}{p+1} . \Sigma(x_2 - x_1), \text{ very nearly.}$$

Or

$$M_{XX} = a . \Sigma(x_2 - x_1) \text{ very nearly,}$$

where a, the scale of the grid, is constant and equal to $\delta(y^{p+1})/(p+1)$.

Thus, the given area is divided into a number of strips parallel to XX. By making the increment $\delta(y^{p+1})$ across each strip common to all strips, it is arranged that each inch of length of each strip very nearly has a fixed value of the required moment about XX, namely, $\delta(y^{p+1})/(p+1) = a$. Then, the strips being drawn, the required moment is equal to the sum (with due regard to sense) of the lengths of the strips multiplied by the scale a.

A pictorial representation of the appropriate process is shown in Fig. 3, wherein a curve of y^{p+1} against y is drawn. The axis of y^{p+1} is divided into equal intervals $\delta(y^{p+1})$, and the corresponding spacings of y are determined by projection. Thus the full lines which are superimposed on the irregular area represent parallel strips, all of which have the same value of the increment $\delta(y^{p+1})$, as required by the theory.

Alternatively, the spacing of the strips could be determined by calculation, but it is not necessary to do so. The strips being defined, the task is then to estimate the "lengths" of the strips intercepted by the given figure, and clearly this may be done most conveniently if each element is represented simply by some "centre line" whose intercepted length may be assumed equal to the effective "length" of the strip. One solution would be to use the geometric

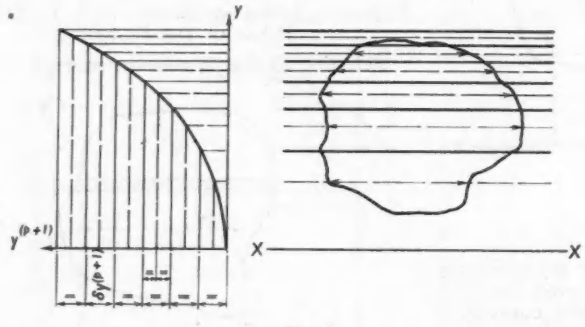


Fig. 3

centre lines, but in general this is neither so convenient nor so accurate as taking the value of y corresponding to the mean value of y^{p+1} for each element. Thus, the centre lines of each interval of y^{p+1} are erected in Fig. 3, and the corresponding "centre lines" of the elements are determined by projection, as shown by the interrupted lines. In order to draw the grid, it is the positions of these centre lines that must be determined, and they may be calculated as follows.

Let $\bar{y}$ denote the distance of a "centre line" from the axis. The value of y, and therefore of y^{p+1}, at the axis is zero. Furthermore, the increment $\delta(y^{p+1})$ across each strip equals $a(p+1)$. Clearly, then :

For the 1st strip :

$$(\bar{y}_1)^{p+1} = \tfrac{1}{2} a(p+1) = (1 - \tfrac{1}{2}) a(p+1).$$

For the 2nd strip :

$$(\bar{y}_2)^{p+1} = 1\tfrac{1}{2} a(p+1) = (2 - \tfrac{1}{2}) a(p+1)$$

For the nth strip :

$$(\bar{y}_n)^{p+1} = (n - \tfrac{1}{2}) a(p+1)$$

i.e.

$$\bar{y}_n = \{(n - \tfrac{1}{2}) . a . (p+1)\}^{\frac{1}{p+1}}.$$

As an example, Fig. 4 illustrates the complete procedure for calculating the grid spacings and determining the second moment of area about XX of the irregular figure shown by interrupted lines. The table to the left shows the calculation of the spacings of the first fifteen "centre lines" for a scale of 1in≡0·5in⁴. Usually, of course, the grid overlay would be readily available, and would simply be chosen from a previously prepared set drawn to four or five different scales. Also rather more than fifteen lines would usually be included ; perhaps about twenty-five. The selected grid is superimposed on a scale drawing of the irregular figure with the axis of the grid placed to coincide with XX, and the lengths of the intercepts made by the figure are recorded in the table to the right. Then the second moment of the figure (to the size drawn) about XX is given by the product of the grid scale and the sum of the lengths of the intercepts.

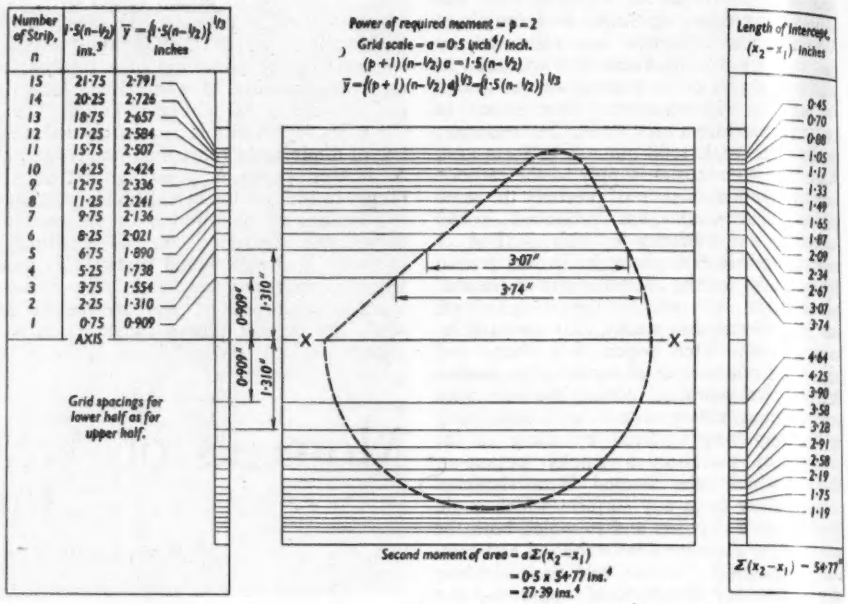


Fig. 4

It should be noted that in the above example all the lengths were reckoned positive, but in general the sum must be taken with due regard to sense. An element of area is always reckoned positive, and thus for even powered moments (the second, fourth, sixth, &c.), all intercepts are reckoned positive, whilst for odd moments each intercept is reckoned positive or negative according as the grid line is to the positive or negative side of the axis.

Since the axis is not a "centre line" the length of its intercept should not be included in the summation. For obvious reasons it is advisable to mark the axis of the grid by a distinguishing colour.

Moments About a Pair of Rectangular Axes in the Plane of the Figure

Turning now to the more general case, the required moment is :

$$M_{XY} = \Sigma dA . y^p x^q.$$

Evidently a strip element is no longer appropriate, so a rectangular element $dx \times dy$ is taken. Then :

$$M_{XY} = \Sigma(dx . dy) . y^p . x^q.$$

The elements are so chosen that each of the products $y^p . dy$ and $x^q . dx$ are common to all elements, and then

$$M_{XY} = (y^p . dy)(x^q . dx) . N.$$

where N is the number (with due regard to sense) of elements included within the area under consideration.

Thus :

$$M_{XY} = \frac{d(y^{p+1})}{(p+1)} \cdot \frac{d(x^{q+1})}{(q+1)} . N$$

and for finite elements :

$$M_{XY} = \frac{\delta(y^{p+1})}{(p+1)} \cdot \frac{\delta(x^{q+1})}{(q+1)} . N \text{ very nearly}$$

i.e.

$$M_{XY} = a . b . N \text{ very nearly.}$$

This result is so similar to that for a single axis that the method should be clear from Fig. 5. Again, the strips are represented by full lines and their "centre lines" by interrupted lines. Each of the rectangular elements is now represented by a point, the point of intersection of two centre lines, and each has a constant value of the required moment equal to $a \times b$. Thus N in the above equation is simply the number of intersections of "centre lines" contained within the area under consideration.

Rather than rule both sets of lines on a single sheet, it will usually be preferable to use two grids, each of which refers to a moment about a single axis. These grids should be superimposed on a scale drawing

of the figure and on one another, the axis of one being placed to coincide with XX, and the axis of the other with YY.

The moment of this type that is most often required is the product moment defined by $\Sigma dA \,.\, x \,.\, y$, i.e. by $\Sigma(y \,.\, dy)(x \,.\, dx)$. To evaluate a product moment, two first moment grids are appropriate.

A moment with respect to a single axis may be treated as a special case (in which q (or p) is zero) of a moment with respect to a pair of axes. This leads to a result in a form that is somewhat different from that given in an earlier section. Thus :

$$M_{XX} = \Sigma dA \,.\, y^p.$$
$$= \Sigma(y^p dy) \,.\, dx.$$

By this method one of the grids consists of parallel lines a fixed distance δx apart, and now the required moment is determined by counting points rather than measuring lines. (Effectively the length of each strip is then estimated by counting the number of intercepts it makes with lines at a fixed distance apart.) The method of counting points is probably the more convenient, but it is evidently rather less accurate.

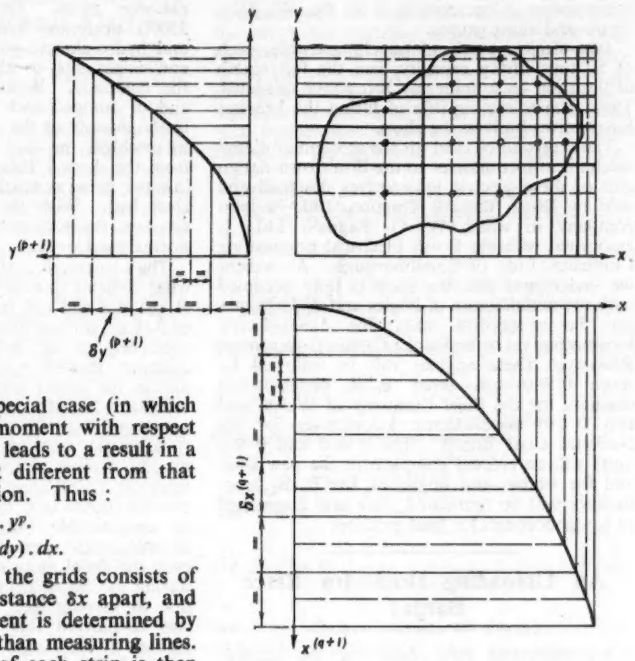


Fig. 5

Moments About a Polar Axis

Fundamentally there is no restriction upon the inclination of an axis about which a moment may be taken, but in practice it is usually not necessary to consider axes other than those in the plane of the figure and those normal to it. Normal axes are called polar axes.

Referring to Fig. 1, a polar axis (seen end on) may be represented by O, and the sth moment about that axis is given by :

$$M_O = \Sigma dA \,.\, r^s.$$

Considering a segmental element $r \,.\, d\theta \times dr$ concentric upon O :

$$M_O = \Sigma(r \,.\, d\theta \,.\, dr) r^s$$

i.e.

$$M_O = \Sigma r^{(s+1)} dr \,.\, d\theta.$$

If the spacings of the rings are so chosen that $r^{(s+1)}dr$ is common to all rings :

$$M_O = \{d(r^{s+2})/(s+2)\} \Sigma d\theta$$

and for finite elements :

$$M_O = \{\delta(r^{s+2})/(s+2)\} \Sigma(\theta_2 - \theta_1) \text{ very nearly,}$$

i.e.

$$M_O = c \,.\, \Sigma(\theta_2 - \theta_1) \text{ very nearly,}$$

where $(\theta_2 - \theta_1)$ is the angle subtended by the figure in each ring.

Again, the method should be clear from Fig. 6, and various methods suggest themselves for estimating the values of $(\theta_2 - \theta_1)$. Perhaps the best method would be to arrange for the sheet on which the grid is marked to rotate about O. Then the datum of θ on the grid could be brought to coincide with one end of each ring in turn, when the angle subtended by the element would be indicated at its further end. Alternatively the grid could be replaced by an arm having suitably spaced divisions along its length, and which was arranged to rotate about O. Then a free-wheeling revolution counter carried on the arm could be used to measure and add the angles subtended by the elements. Yet again, the increments $\delta\theta$ could be kept constant as well as the increments $\delta(r^{s+2})$, when each element of $\delta\theta$ could be represented by the mean radial line, as shown in Fig. 6.

Then :

$$M_O = c \,.\, \delta\theta \,.\, N$$

where N is the number of intersections of circular and radial centre lines contained within the given area.

General Remarks

In what has gone before the question of moments of area has been treated more or less generally, yet it must be acknowledged that interest seldom extends beyond areas (A), first moments (ΣdAy), second moments (ΣdAy^2), product moments ($\Sigma dAxy$) and polar second moments ($\Sigma dA \,.\, r^2$). For moments having positive powers such as these, the grid spacings become closer as they become more distant from the axis, and for this reason it is necessary to match to a degree the scale of the grid and the overall dimension of the figure measured at right angles to the moment axis. Too small a scale is inconvenient because of the large number of "centre lines" involved and because of their very close spacing, whilst too large a scale leads to inaccuracy because too few "centre lines" are involved. Thus, any one grid is suitable for use only in a certain, if flexible, range, and it is necessary in general to provide a number of grids to different scales for each type of moment that must be measured.

In order to keep the number to a minimum some thought should be given to procedure and to the choice of scales, but such considerations may not be treated in a general way because the arguments must vary as the requirements vary. However, a few general observations may usefully be made.

First, it is usually a great convenience if the figures are drawn always to such scales that the greatest overall dimension approximates to some fixed value. A figure of about 10in gives a good compromise between accuracy and convenience. Secondly, if the axes about which moments are to be taken are far removed from the "centre" of the figure, it is advisable to use the grids on axes which are parallel to the given axes but are placed near the estimated "centre." This reduces the number of grids required by virtually cancelling one variable—the distance of the axis from the figure—and makes for greater accuracy as well as a more convenient grid scale. The process of "transferring" a moment to parallel axes is usually quite simple. There is yet another point of interest in that, although the centre of area is usually defined by reference to first moments of area, it is not necessary to determine first moments specifically in order to locate the centre of area. Referring to Fig. 7, suppose that the second moment of area of the irregular figure about a polar

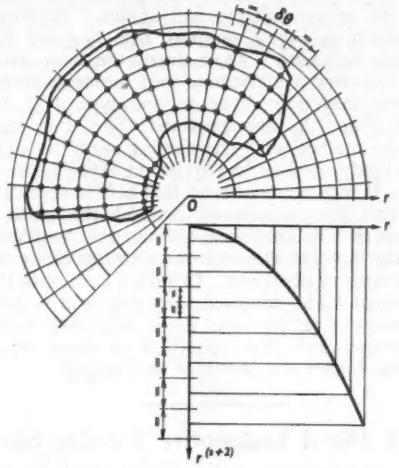


Fig. 6

axis through the centre of area G is required. The obvious method would be to measure the area, and the first moments of area about two arbitrarily chosen axes in order to determine the position of G, and then to determine the polar moment about G directly. Apart from the area (which could, of course, be determined by means of a grid if required), the above method would usually require three grids of two types. Suppose, however, that the area and three polar second moments about B, C and D were determined. In Fig. 7, B, C and D are drawn remote from the figure in the

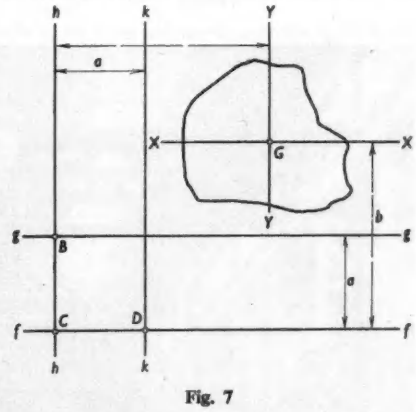


Fig. 7

interests of clarity, but in practice they would be chosen grouped around the estimated position of G. Using the polar axis and the parallel axis theorems, and denoting a second moment of area by I :

$$I_C = I_{ff} + I_{hh}.$$
$$I_B = I_{gg} + I_{hh}.$$
$$I_C - I_B = I_{ff} - I_{gg}.$$

But

$$I_{ff} = I_{XX} + Ab^2$$

and

$$I_{gg} = I_{XX} + A(b-a)^2$$

Therefore

$$I_{ff} - I_{gg} = I_C - I_B = A(2ba - a^2)$$

Therefore

$$b=\left(\frac{1}{2a}\right)\left\{(I_C-I_B)/A+a^2\right\}.$$

Similarly,

$$c=\left(\frac{1}{2a}\right)\left\{(I_C-I_D)/A+a^2\right\}$$

and

$$I_G=I_C+A(b^2+c^2).$$

Apart from the area, this method requires only one grid.

Many such manœuvres are possible, but one more example will suffice. Referring again to Fig. 7, suppose that I_{XX} and I_{YY} are required. Apart from the area, it is necessary to determine four moments in all, but they may all be of one type if I_{ff}, I_{gg}, I_{hh}, and I_{kk} are measured. In this case the method of "transferring axes" is sufficiently obvious to require no explanation.

It may be mentioned that care is necessary with narrow sections in which the width is much less than one-quarter the length, if the moment axis runs more or less along the length of the figure. In such a case, with the small scales involved, any one grid is only convenient for use in a relatively small range, and this condition is more acute the higher the power of the moment.

A Diesel Locomotive Erecting Shop

A NEW shop particularly intended for the erection of diesel locomotives has been opened at the Castle Engine Works, Stafford, of W. G. Bagnall, Ltd. Hitherto this class of locomotive has been built in the same shops as the steam and fireless locomotives made by the firm, but the increasing demand for diesel locomotives made increased erection capacity necessary.

The new shop, one end of which can be seen in the photograph reproduced on this page, is of heavy steel construction carried on continuous reinforced concrete foundations. It is 175ft long by 43ft wide and is 40ft high to the eaves. Brick walls are built to a height of 11ft and the remainder of the building is clad with corrugated asbestos sheeting.

Two sets of tracks run the full length of the shop and are set flush in the granolithic floor. One track is of mixed gauge and provides for the construction of locomotives of 5ft. 6in., 4ft. 8½in, 3ft 6in and metre gauges.

Two electric overhead travelling cranes, each of 50 tons lifting capacity, run the full length of the shop on a craneway 30ft above rail level. These cranes are capable of lifting the heaviest locomotives built in the shop.

The shop will be used for the erection of diesel-mechanical locomotives to the firm's own design and of diesel-electric locomotives designed and sold by Brush Bagnall Traction, Ltd.—a joint company in which W. G. Bagnall, Ltd., is associated with the Brush Electrical Engineering Company, Ltd., of Loughborough. At present we understand that the shop is fully occupied with the manufacture of bogies and underframes for the twenty-five main line diesel-electric locomotives on order for the Ceylon Government Railway. These engines will be followed by seven 0–4–0 and three B_0–B_0 diesel-electric shunters for the Steel Company of Wales, and two 0–6–0 diesel-electric locomotives for the National Coal Board. The 0–4–0 and 0–6–0 units will be erected complete in the new shop and the frames and bogies of the B_0–B_0 locomotives will be fabricated there and dispatched to Loughborough for final erection.

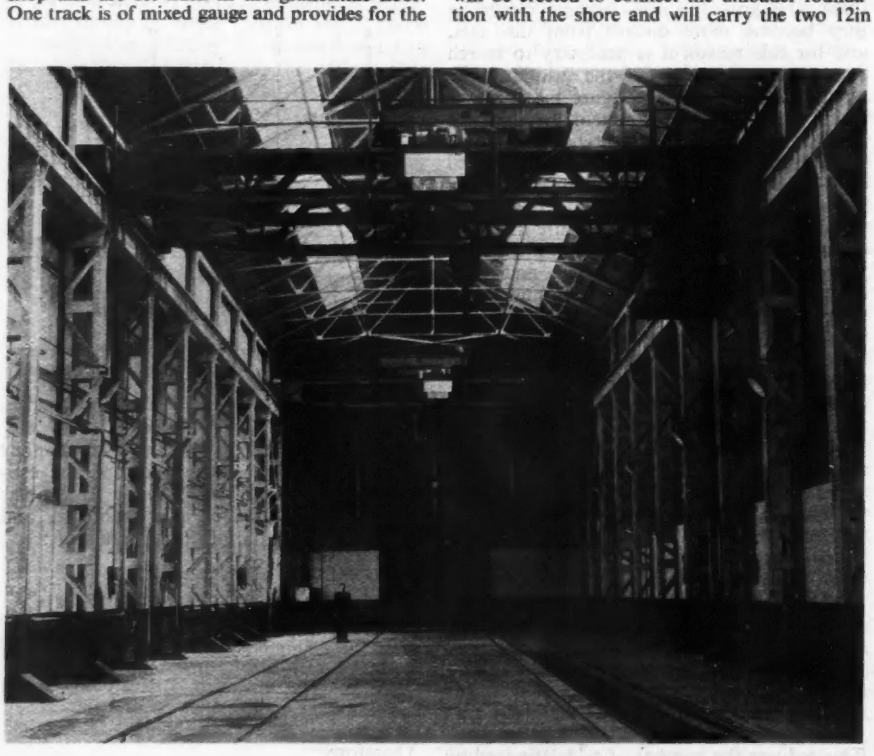
An Unloading Dock for River Barges

(By Our American Correspondent)

AN interesting river dock for the unloading of barges containing "river coal," or coal-laden silt, is currently being built on the Susquehanna River at Safe Harbor, Pennsylvania, for the Pennsylvania Water and Power Company by the contracting division of the Dravo Corporation, Pittsburgh. The dock consists of a row of eight 20ft diameter steel sheet pile cells, along which barges will be moored and moved. At the mid-point of the dock there is a twin cell foundation of larger diameter which will support the coal unloading unit. This straight-line unloader will have a 5-ton bucket and will be able to transfer some 500 tons per hour of the coal-laden silt from the barges to a hopper. On leaving the hopper, the coal material is mixed with water, and the resulting solution is pumped through two 12in pipes to the processing plant. The hopper, the solution tanks and the pumping equipment will all be mounted on the twin-cell foundation of the coal unloader. A 10ft wide service bridge will be erected to connect the unloader foundation with the shore and will carry the two 12in diameter pipes. The dock is situated about 3300ft upstream from the Safe Harbor dam and hydro-electric power station, at the closest convenient site to the coal washing plant of the company. Because of the rugged terrain and of dumped rock fill adjacent to the shore in the vicinity of the dock site, it was necessary to establish the face of the dock about 115ft from the shore. This placed the sheet pile cells in water rising as much as 65ft above the original river bed. With the reservoir level relatively constant, the dock cells extend only 8ft above the normal pool level.

The construction of the cells was made somewhat difficult due to the unusually deep water at the site and the fact that more than 30ft of coal-laden silt had been deposited on the original rock bed of the river. This unstable, non-cohesive material provided no firm support during the initial setting of the sheet piles, a condition, which, coupled with an exaggerated saw-toothed surface of the rock, made it difficult to keep the cells vertical. During the winter months a sheet of ice sometimes forms on the reservoir to a considerable thickness. When this ice moves out, there are shoreward thrusts of considerable magnitude. The sheet pile mooring cells were designed to withstand not only the usual mooring forces of loaded barges during the operating season, but also this thrust due to moving ice. In designing the cells, it was considered that the overturning force is resisted by the weight of the sheet piling and the material filling the cell, and no account was taken of the questionable passive resistance of the 30ft of coal-laden silt overlying the rock. To provide maximum strength for the smallest diameter cell, it was necessary to remove all of the silt inside the ring of sheet piling, and fill the cell with a heavy pervious material which is capable of establishing a high shear value. Calculations showed that a properly filled 20ft diameter cell would resist the overturning loads with an adequate factor of safety.

To provide the floating equipment necessary to build the dock, the contractor used the pontoon cube system which was used extensively during the last war. Individual 5ft by 7ft by 5ft pontoons were fastened together to create a floating base for the construction equipment. The construction of the dock consisted principally of pitching and driving the sheet piling forming the cells, digging the undesirable silt from inside these cells, and filling them with dense material. To facilitate both the pitching of the sheet piling and the dredging of the silt material, a dual-purpose template-bracing unit was built and used at each cell. The 16-ton, 32ft high units, were lifted into position with the aid of floating cranes and each held in proper alignment with four H-beam piles. Subsequently, the flat web sheet piling was set around each template and driven firmly into rock. Clamshell buckets then dredged the unstable silt from inside the cell. As this excavation proceeded, the bracing unit was forced down to within 10ft of the rock to provide positive support for each sheet pile. The bracing frame thus prevented the pressure due to the 30ft depth of external silt from collapsing the cylinder during excavating and filling. After the cells had been excavated to rock, dense fill was placed up to the bottom of the bracing units, and the latter were then withdrawn in steps. To obtain the dense, shear-resisting cell fill, rock and sand had to be delivered to the site. This fill was mixed in place by alternating loads of the different materials with some further agitation by the clamshell bucket within the cell. With this special fill placed from the rock bottom to the top of the cell, it is believed that a structure has been obtained which will resist the thrust from the moving ice or barges. The twin-cell foundation for the coal unloading unit consists of two 35ft 6in diameter cells, which were constructed in the same manner as the 20ft cells. These cells were joined by sheet pile arcs, and the enclosed area was filled with cell fill material. Steel H-beam bearing piles were driven within each cell to carry the large loads from the unloader columns. A 24in concrete cap with a 4ft deep circumferential girder was poured over the entire foundation. This cap was designed to be supported by the sheet piling, in conjunction with the bearing piles, and will carry pumps and other machinery.



Diesel Locomotive Erecting Shop

The Solution of Transient Heat-Flow Problems by Analogous Electrical Networks*

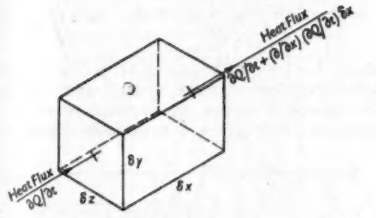
By D. I. LAWSON, M.Sc.,† and J. H. McGUIRE, B.Sc.†

No. I

The design of a machine for solving heat conduction problems by their electrical analogy with the flow of current in series resistance, shunt capacitance networks, is described in this paper. Consideration is given to the representation of cooling by radiation and convection, and the design of the circuits is discussed.

THE work described in this paper was undertaken to provide means for the rapid determination of the temperatures inside materials and composite structures when heated under conditions similar to those occurring in fires. Often it is not possible to obtain analytical solutions to such problems and, even when they can be found, the labour of computing is considerable.

The flow of heat in materials not maintained at a uniform temperature obeys laws similar to those that govern the flow of charge in suitably designed electrical networks, and several



Net rate of heat gain by element
$$=\partial Q/\partial t-\{\partial Q/\partial t+(\partial/\partial x)(\partial Q/\partial t)\delta x\}$$
therefore
$$(\partial/\partial x)(\partial Q/\partial t)\delta x=\text{mass of element} \times \text{rate of rise of temperature} \times \text{specific heat of material}$$
$$=\rho \,.\, S \,.\, \delta x \,.\, \delta y \,.\, \delta z \,.\, \partial\theta/\partial t,$$
or
$$(\partial/\partial x)(\partial Q/\partial t)=\rho \,.\, S \,.\, \delta y \,.\, \delta z \,.\, \partial\theta/\partial t$$

Fig. 1—Flow of Heat in an Elemental Prism

machines have been described in which this or other analogies have been exploited [see references]. Such analogue machines are broadly divisible into two classes, depending on the time scale of the experiments and therefore on the method of presenting the results.

The apparatus for the work described in this paper has been designed to give cathode ray tube presentation of results, for problems in which the boundary condition at the heated surface is a prescribed time-temperature curve. The limitations inherent in a "fast" time scale apparatus are not important in the application for which the machine is intended, since only two alternative boundary conditions are required at the heated surface, and since the accuracy of the data available for problems makes the representation of variations of thermal properties with temperature a refinement only. A novel feature of the apparatus is the introduction of non-linear circuit elements to simulate the loss of heat by radiation and convection cooling.

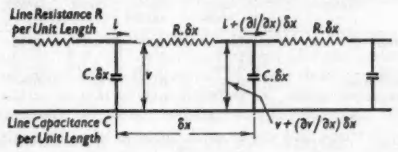
An attempt has also been made to assess on theoretical grounds the factors governing the design of electrical networks representing heat transmission problems.

Notation

A—Area of cross section.
a, b—Parameters determining voltage current characteristic of "Metrosil," $i=av^b$.
C—Shunt capacitance per unit length of network.
E—Electromotive force.
g—Mutual conductance.
H—Convection coefficient.
$I_r(\lambda)$—Modified Bessel function of first kind and rth order.
i—Current.
K—Thermal conductivity.
k—Thermal diffusivity.
L—The Laplacian transform.
m, n—Scaling factors.
p—The Heaviside operator.
Q—Quantity of heat.
q—Quantity of electricity.
R—Resistance per unit length.
r—Number of sections of iterated network.
S—Specific heat.
T—Absolute temperature.
T_A—Ambient temperature.
t—Time.
V—Volume of liquid.
v—Voltage.
$\bar{v}$—The Laplacian transform of v.
x, y, z—Cartesian co-ordinates.
Z—Impedance transform.
α—Equivalent length of section ; also used as a fraction.
β—A fraction.
γ and μ—Defined by $\operatorname{erf}\gamma=(2/\sqrt{\pi})\left(\int_0^{\gamma} e^{-\mu^2}d\mu\right)$.
δ—$1+Z'/2Z$.
ε—Emissivity factor.
θ—Temperature difference due to heat flow.
λ—Defined by $\lambda=2t/(\alpha^2RC)$.
λ_1—Defined by $\lambda_1=2t/(RC)$.
ρ—Density.
σ—Stefan-Boltzmann constant.
Ψ—Coefficient of Newtonian cooling.

* Institution of Mechanical Engineers. Written discussion of this paper was invited by the Institution.

† Department of Scientific and Industrial Research and Fire Offices' Committee, Joint Fire Research Organisation.



Voltage change along length $\delta x=v-\{v+(\partial v/\partial x)\delta x\}$
$$=-(\partial v/\partial x)\delta x$$
$$=R \,.\, \delta x \,.\, i$$
therefore
$$i=-(1/R)(\partial v/\partial x)$$
Change in current flow per unit length
$$=i-\{i+(\partial i/\partial x)\delta x\}$$
$$=-(\partial i/\partial x)\delta x$$
$$=C \,.\, \delta x(\partial v/\partial t)$$
therefore
$$\partial i/\partial x=-C(\partial v/\partial t).$$

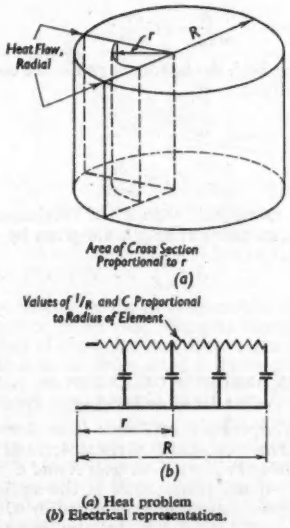
Fig. 2—Flow of Current in a Series-Resistance Shunt-Capacitance Transmission Line

Flow of Heat in Solids

Equations Governing the Flow of Heat in Solids.—If the temperature of a body varies throughout its volume, heat will be transferred from the hotter to the cooler regions. The unidirectional flow through any elemental volume will be completely described by the following statements (Fig. 1) :—

(1) The rate of flow of heat across any face of the volume will be proportional to the temperature gradient normal to the face.

(2) The difference in the rate of flow of heat between two parallel faces will be equal to the heat absorbed in raising the temperature of the elemental volume.



(a) Heat problem
(b) Electrical representation.

Fig. 3—Electrical Network to Simulate Heat Flow in a Cylinder

Thus, if the element under consideration has dimensions δx, δy, and δz the first and second statements give respectively

$$\frac{\partial Q}{\partial t}=-K\delta y\delta z\frac{\partial\theta}{\partial x} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$\frac{\partial}{\partial x}\left(\frac{\partial Q}{\partial t}\right)=-\rho S\delta y\delta z\frac{\partial\theta}{\partial t} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where $\partial Q/\partial t$ is rate of flow of heat through area $\delta y\delta z$; θ, temperature difference due to heat flow in the x direction ; K, thermal conductivity ; ρ, density ; and S, specific heat. The negative signs indicate that the heat flow is considered to be positive in the direction in which θ is diminishing. From equations (1) and (2) two further equations may be obtained by substitution.

$$\frac{\partial\theta}{\partial t}=\frac{K}{\rho S}\frac{\partial^2\theta}{\partial x^2} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

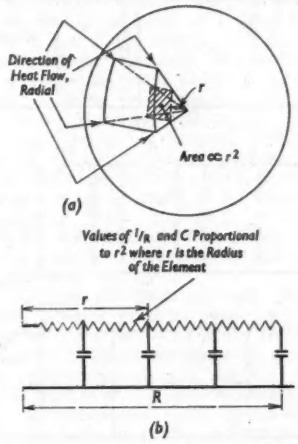
$$\frac{\partial^2 Q}{\partial t^2}=\frac{K}{\rho S}\frac{\partial}{\partial t}\left(\frac{\partial^2 Q}{\partial x^2}\right) \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Similar expressions could be written for the flow of heat in the other co-ordinate directions, but the arguments will be limited for the sake of simplicity to unidirectional flow. This being so, it is unnecessary to restrict the area through which the heat is considered to flow to the area $\delta y\delta z$, and this will be replaced by A, giving :—

$$\frac{\partial Q}{\partial t}=-KA\frac{\partial\theta}{\partial x} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$$\frac{\partial}{\partial x}\left(\frac{\partial Q}{\partial t}\right)=-A\rho S\frac{\partial\theta}{\partial t} \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Analogy Between the Thermal and Electrical Problems.—If a uniform transmission line is constructed to have a resistance R and a shunt capacitance C per unit length, a simple application of Kirchhoff's laws gives the following relations (Fig. 2) :—



(a) Heat problem
(b) Electrical problem

Fig. 4—Electrical Network to Simulate Heat Flow in a Sphere

$$i=-\frac{1}{R}\frac{\partial v}{\partial x} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

$$\frac{\partial i}{\partial x}=-C\frac{\partial v}{\partial t} \quad . \quad . \quad . \quad . \quad . \quad (8)$$

where i is the current and v the voltage. A combination of equations (7) and (8) gives :—

$$\frac{\partial v}{\partial t}=\frac{1}{RC}\frac{\partial^2 v}{\partial x^2} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

$$\frac{\partial i}{\partial t}=\frac{1}{RC}\frac{\partial^2 i}{\partial x^2} \quad . \quad . \quad . \quad . \quad . \quad (10)$$

Remembering that $i=\partial q/\partial t$, where q is the quantity of electricity, it will be seen that the equations (3), (4), (5), and (6) are respectively of the same form as equations (9), (10), (7), and (8) ; and thus an electrical representation may be made of any heat problem provided the analogies shown in Table I are maintained.

TABLE I—*Analogous Thermal and Electrical Constants*

Heat problem		Electrical problem	
Thermal conductivity × area	KA	Conductance per unit length of transmission line	$1/R$
Area × density × specific heat ; that is, thermal capacity per unit length	$A\rho S$	Capacitance per unit length of transmission line	C

It follows that the thermal diffusivity $k=K/\rho S$ is represented by the expression $1/RC$ and that the variables in the heat problem will be represented

by the electrical quantities shown in Table II.

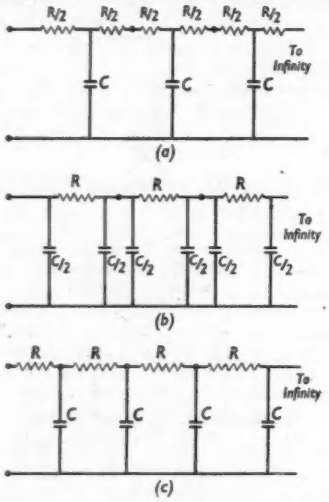
For a transmission line designed to represent unidirectional heat flow it is convenient to construct the network to represent unit cross-sectional area, and to scale the current to any other cross-sectional area.

Use of Transmission Lines to Represent the Flow of Heat in Cylinders and Spheres.—The one-dimensional representation already described

TABLE II—*Analogous Thermal and Electrical Variables*

Heat problem		Electrical problem	
Quantity of heat	Q	Quantity of electricity	q
Flow of heat	$\partial Q/\partial t$	Current	i
Temperature difference	θ	Potential difference across transmission line	v

may be used in the determination of the flow of heat, and of the temperature at points inside cylinders and spheres, when the surface temperature is raised in some prescribed manner with time. In such problems the flow of heat will be radial ; and if a section of the cylinder is considered, the area through which the heat is flowing will decrease proportionately with the distance from the centre. The appropriate network



(*a*) Line composed of T sections
(*b*) Line composed of π sections
(*c*) Line composed of ⅂ sections

Fig. 5—Methods of Construction

would consist of resistive elements which increased, and of capacitative elements which decreased, proportionately with the distance along the line (Fig. 3). In the case of heat transmission in spheres, the resistive and capacitative elements would vary with the square of the distance along the line (Fig. 4).

Design of Transmission Lines to Simulate Heat Conduction Problems

The Primary Transmission Line Constants Required for the Electrical Representation of the Problem.—Referring to the pairs of analogous equations (3)–(6) and (7)–(10), it will be seen that if scales of 1 calorie per coulomb and 1 Centigrade degree per volt are adopted for the heat flow through unit area, then the following numerical equalities must be maintained :—

$$R=\frac{1}{KA} \quad . \quad . \quad . \quad . \quad . \quad (11)$$

$$C=A\rho S \quad . \quad . \quad . \quad . \quad . \quad (12)$$

where R and C are in ohms and farads, and A, K, ρ and S are in c.g.s. units.

Table III shows the primary constants of transmission lines representing unidimensional heat flow through a section of 1 square centimetre of some common materials.

Such values for C could not possibly be obtained in a continuous transmission line, even if the line were sectionalised so that it became an iterated network, the values would be impracticable. One way of overcoming this difficulty is to reduce the time scale of the electrical representation ; indeed, this is desirable from another point of view, since the transmission of heat in some materials takes place only slowly and it would be a great advantage to reduce the time taken for the solution of a problem in the electrical representation. It would also be convenient to modify the scale of R, since the values shown in Table III would lead to the drawing of

TABLE III—*Primary Constants of Transmission Line*
Unidimensional heat flow through unit area in common materials

Material	K, c.g.s. units	ρS, c.g.s. units	R, ohms	C, farads
Silver	1·0	0·58	1·0	0·58
Steel	0·11	0·93	9·0	0·93
Lead	0·084	0·34	11·9	0·34
Limestone	0·004	0·55	250	0·55
Spruce (with grain)	0·00055	0·12	1820	0·12

heavy currents from the generator if practicable values of voltage were applied to the line.

Modification of the Values of the Primary Constants Required by Altering the Time Scale of the Electrical Representation.—The values of any of the electrical quantities, representing either variables (θ, $\partial Q/\partial t$, x, and t) or constants (K, ρ, and S) in the thermal problem, may be scaled by any factor. Such action, however, automatically entails the changing of one or more of the remaining quantities to preserve the equalities of equations (7) and (8). As equations (9) and (10) are derived from equations (7) and (8), it follows that they also will remain consistent. In particular, the requirements of electrical representation have shown that this modification is necessary with regard to the values of capacitance and resistance. Thus if the value of capacitance is multiplied by a factor n, both the equalities (7) and (8) are preserved merely by modifying the time scale. Equation (7) remains unchanged and equation (8) becomes

$$\frac{\partial i}{\partial x}=-nC\frac{\partial v}{n\partial t} \quad . \quad . \quad . \quad . \quad . \quad (13)$$

If the value of resistance is changed, the equalities cannot be preserved merely by altering one other parameter. Modification of the x scale will be abortive and the scale of v is conditioned by the methods of measurement available. The most convenient solution is to modify the scales of i and t. If the scale of i is divided by the factor m, equations (7) and (8) become

$$\frac{i}{m}=-\frac{1}{mR}\frac{\partial v}{\partial x}$$

and

$$\frac{1}{m}\frac{\partial i}{\partial x}=-C\frac{\partial v}{m\partial t}.$$

Including both the factors m and n, the equations are therefore

$$\frac{i}{m}=-\frac{1}{mR}\frac{\partial v}{\partial x}$$

and

$$\frac{1}{m}\frac{\partial i}{\partial x}=-nC\frac{\partial v}{mn\partial t}.$$

The numerical values of resistance and capacitance per unit length are given by

$$R=\frac{1}{mK} \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

and

$$C=\frac{1}{n}.\rho S \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

Factors Affecting the Design of Networks Simulating Heat Conduction Problems

The Temperature at Points in a Semi-Infinite Slab and the Potential Difference Across a Smooth Line Having Primary Constants R and C per Unit Length.—If the temperature at the surface of a semi-infinite slab is suddenly raised by θ_0 degrees, it may readily be shown that the temperature θ at a distance x is

$$\theta=\theta_0\left\{1-\operatorname{erf}\frac{x}{2}\left(\frac{1}{kt}\right)^{\frac{1}{2}}\right\} \quad . \quad . \quad . \quad (16)$$

Where $\operatorname{erf}\gamma=(2/\sqrt{\pi})\int_0^{\gamma}e^{-\mu^2}d\mu$; and $k=K/\rho S$.

In the same way, if the voltage at the sending end of a semi-infinite smooth line is raised by v_0, the potential difference v across the line at any point x is given by

$$v=v_0\left\{1-\operatorname{erf}\frac{x}{2}\left(\frac{RC}{t}\right)^{\frac{1}{2}}\right\} \quad . \quad . \quad . \quad (17)$$

The electrical representation will be a true one (neglecting time scaling for the moment) if the product of the primary constants RC is made numerically equal to $1/k$. It will not be practicable to construct a line having continuous series resistance, and shunt capacitance loading, and the question now arises as to how far an iterated network will be successful in representing the potential differences and hence the temperature changes in the thermal problem.

Iterated Representations of the Smooth Transmission Line.—A smooth transmission line of the type described may be broken up into a series of sections in which the primary constants are lumped together, each section representing a finite length of the original transmission line. The line may be considered to be comprised of a series of either T, π or ⅂ sections, as shown in Fig. 5. The differences in these representations, if the line is infinitely long,‡ occur at the sending end in the first section. It is shown [in an Appendix to the paper] that, irrespective of which representation is chosen, the potential difference across the line after a given number of sections is the same. If each section represents a length α of smooth line having primary constants R and C per unit length, the potential difference across the line after r sections will be

$$v_r=v_0\left\{1-e^{-\lambda}\left(2\sum_0^{r-1}I_n(\lambda)+I_r(\lambda)-I_0(\lambda)\right)\right\} \quad . \quad (18)$$

where $\lambda=2t/(\alpha^2RC)$ and $I_r(\lambda)$ is the modified Bessel function of the first kind and rth order. The potential across the iterated network will represent that across the smooth transmission

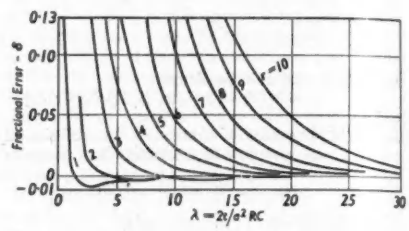


Fig. 6—Fractional Error at the rth Section in Representation of a Continuous Line by a Lumped Line

line in so far as equation (18) approximates to equation (17). In comparing the expressions, the distance x will be replaced by $r\alpha$, since this is the distance along the smooth line represented by r sections of the iterated network. When making this substitution it will be necessary to investigate the range of values over which

$$e^{-\lambda}\left\{2\sum_0^{r-1}I_n(\lambda)+I_r(\lambda)-I_0(\lambda)\right\}\simeq\operatorname{erf}\frac{r}{\sqrt{(2\lambda)}} \quad . \quad (19)$$

From equation (19) it will be seen that the accuracy of the approximation will be governed by two factors : λ and r (the number of sections in the iterated network representing x, the distance along the line). If λ is very large the iterated network will represent the smooth line accurately for

$$Lt_{\lambda\to\infty}e^{-\lambda}\left\{2\sum_0^{r-1}I_n(\lambda)+I_r(\lambda)-I_0(\lambda)\right\}=r\sqrt{\frac{2}{\pi\lambda}}$$

$$=Lt_{\lambda\to\infty}\operatorname{erf}\frac{r}{\sqrt{(2\lambda)}}.$$

This would be expected, for since $\lambda=2t/(\alpha^2RC)$, then, if $\lambda\to\infty$, at least one of the following conditions would hold : $\alpha\to0$, $RC\to0$, $t\to\infty$. The first condition states that the length of line represented by each section of the iterated network must be vanishingly small ; the second states the either one or both of the elements of resistance and capacitance, in each section, must be small. These two conditions are equivalent to a statement that the iterated network must be smooth. The third condition states that the iterated network can only be expected to give perfectly accurate results a long time after the initial disturbance is applied to the sending end. This means that all transient variations in potential along the line will have ceased : the line will have assumed the steady-state condition, and

‡ A line may be said to be infinitely long when at any time the voltage at the remote end is small compared with the voltage at the point of measurement.

therefore the capacitative elements will have ceased to play any part in determining the potential differences along the line. The network can be considered at this state to be purely resistive, and it will function exactly as a smooth transmission line.

So far only the limiting values for the iterated representation of the continuous line have been discussed; but in designing the network more general conditions will have to be studied. Unfortunately, the series of modified Bessel

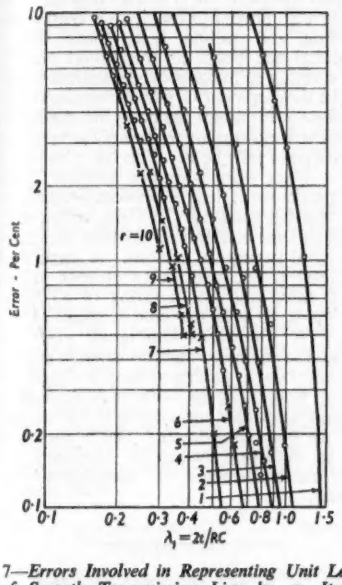


Fig. 7—Errors Involved in Representing Unit Length of Smooth Transmission Line by an Iterated Network Having r Sections per Unit Length

functions does not yield to analytical treatment and it must be computed. The iterated network will have an error of

$$\text{erf}\,\frac{r}{\sqrt{(2\lambda)}} - e^{-\lambda}\left\{2\sum_{0}^{r-1} I_n(\lambda) + I_r(\lambda) - I_0(\lambda)\right\}$$

for any given values of r and λ.

The fractional error δ in the result will be given by

$$\delta = \frac{\text{erf}\,\frac{r}{\sqrt{(2\lambda)}} - e^{-\lambda}\left\{2\sum_{0}^{r-1} I_n(\lambda) + I_r(\lambda) - I_0(\lambda)\right\}}{1 - \text{erf}\,\frac{r}{\sqrt{(2\lambda)}}}.$$

These results have been plotted for a range of values of r and λ in Fig. 6, where the error decreases with increasing λ. The error for any given value of λ increases with r. In other words, the greater the distance at which measurements are made from the sending end of the network, the greater will be the error δ for any given value of λ. This point need not give rise to any concern, for the farther measurements are made from the sending end, the greater will be the time available for the potential to rise to a given value, since equations (17) and (18) are functions of $x/\sqrt{t}$. It follows therefore that for different points along the line equal potential differences will occur after a time t, where $t \propto x^2$, or, for an iterated network, t will vary as r^2. Consequently, as r increases, the only values of t likely to be of interest will increase as r^2; and since $\lambda \propto t$, the values of λ that are important increase as r^2. When this factor is taken into account the errors will decrease progressively as the measurements are made farther along the network.

Apart from making the line accurate by designing it so that each section represents only a small length of the smooth line (α small), it would appear that the accuracy might be improved by scaling to use small values of the product RC (as when modifying the values of the primary constants). This improvement is illusory, however, for C can only be reduced by shrinking the time scale proportionately; therefor t/C remains constant. Further, if R is reduced by scaling, then the value of C must be increased in the same ratio. This leaves the product RC, and therefore the value of λ, constant; hence the accuracy is left unaltered.

Since $\lambda \propto (t/\alpha^2)$, there is a certain equivalence between the speed at which results of a given accuracy are reached and the coarseness of the network. If the length of the smooth line represented by each section of the network is doubled, then the time at which the network will give results of any given accuracy must be increased by a factor of four.

Another useful way of portraying the curves of Fig. 6 would be to make them all refer to unit length of line. This would enable a determination to be made of the number of sections of the iterated network necessary to represent unit length of the smooth line when any given accuracy was required at any particular time after the experiment had begun. This is done by replacing α by $1/r$ in the value of λ used in equation (18); the new set of curves, representing the error when r sections represent unit length, is obtained by shrinking the λ values for each curve of Fig. 6 by a factor $1/r^2$ (since $\lambda = 2t/\alpha^2 RC = 2tr^2/RC$). When reduced by the factor r^2, the new values of λ will refer to unit length of line and will be denoted by $\lambda_1 = 2t/(RC)$. Fig. 7 shows the fractional error δ as a function of λ_1, for lines having different numbers of sections per unit length. The error associated with any given value of λ_1 is reduced as the number of sections per unit length of line is increased. The number of sections per unit length necessary for any given accuracy will depend on the value of λ_1 (which is equivalent to $2t/RC$), and therefore on the value t. Fig. 8 shows the number of sections required to represent the behaviour of a smooth line with accuracies of 2, 1 and ½ per cent for various values of λ_1. For example, when measurements are made at points in excess of unit length from the beginning of the line: 4, 5½ and 7 sections per unit length will give accuracies of 2, 1 and 0·5 per cent respectively, for values of $\lambda_1 = 2t/(RC)$ of 0·46. For values of $\lambda_1 = 1{\cdot}0$ one section per unit length will give an accuracy of 2 per cent, while two sections per unit length will be adequate for accuracies of 0·5 per cent.

The whole question of design is dependent upon the time that can be allowed to lapse between the application of the impulse to the line

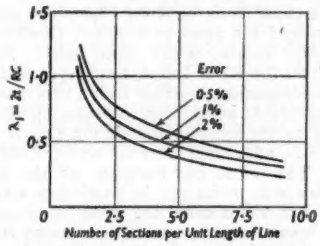


Fig. 8—Number of Sections per Unit Length of Iterated Network to Represent Smooth Line with Accuracies of ½, 1 and 2 per cent

and the making of the measurements. It is only necessary to make measurements rapidly at the beginning of the line; the disturbance will take some time to be propagated to other points and therefore the line may be made increasingly coarse as the length increases.

If it is desired to design the line with a given accuracy (λ contant), α must be made proportional to $\sqrt{t}$, since $\lambda \propto t/\alpha^2$. It has been shown that the signal will have reached a given fraction of its final value at any point after a time t, when t/x^2 = constant. Therefore if the line is to represent the performance of a smooth line with the given accuracy, it follows that $\alpha \propto x$; in other words the length represented by each section of the network may be increased linearly with x the distance—the sections in the second centimetre being twice as coarse as those of the first, and so on.

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(To be continued)

Indian Engineering News

(By Our Indian Correspondent)

Scientific and Industrial Research

With the opening of the Central Building Research Institute at Roorkee, the last of the eleven national laboratories (THE ENGINEER, August 8, 1952) included in the first plan of the Council of Scientific and Industrial Research has started functioning formally. Two more research institutes were formally opened earlier this year, the Central Electro-Chemical Research Institute at Karaikudi, Madras and the Central Leather Research Institute at Madras. In addition, plans are going ahead for the establishment of three more research laboratories, Radio and Electronics Research Institute, Mechanical Engineering Research Institute and Central Salt Research Station. National laboratories in India are strictly a post-war development and it is to the credit of the Council that the ambitious plans involving not only the building but the staffing of such a large number of applied research institutions has been accomplished in such a short time.

The Council of Scientific and Industrial Research, deriving both its inspiration and its constitution from the D.S.I.R. in Britain, has for its objects the undertaking of surveys of natural resources, conducting tests and evolving standards, giving advice to Government and to industry and developing useful processes. In a country like India in which, medium and small-scale producers contribute a considerable proportion of industrial production, the producers are unable to afford research facilities of their own and have to rely on state-financed establishments for the solution of their technical problems. The problems themselves are somewhat different from those besetting highly mechanised and advanced industrial units and are generally more directly concerned with the utilisation of existing indigenous products.

This special approach is evident in the research programmes of most of the institutes. The National Physical Laboratory has been engaged recently in carrying out research on evolving an inexpensive solar cooker for use in poor and middle class households. The experiments appear to have been successful for it was announced last week that two manufacturers in the country have gone into production of these cookers and the first model is expected in the market very soon. The National Metallurgical Laboratory has been engaged on a number of investigations on beneficiation of ores. Investigations are in progress on beneficiation of pyrites, chrome ore, wolfram and other ores found in the country. The Fuel Research Institute has set up a number of stations in different coal fields for carrying out a detailed physical and chemical survey of Indian coals. The Central Road Research Institute has begun studies on materials and soils and is devoting special attention to the problems of rural roads and rural transport. The Central Building Research Institute is investigating the problems connected with providing low-cost houses, and the evolution of cheaper materials in place of traditional building materials like cement and steel. It is at present experimenting with a house of shell-type construction which, it is stated, requires only about a third of the normal quantity of steel used in such building units.

The laboratories work in close collaboration with the universities, through whom they get

most of their qualified staff, with the newly-established post-graduate technical institutes and with the Indian Standards Institution. Naturally there is also a close connection at all levels of investigation with their opposite numbers in the industry and with organisations directly connected with small-scale and cottage industries. Many of the laboratories are under the direction of foreign scientists and a number of research workers are regularly being sent abroad for higher training, mainly in the U.K. and the U.S.A.

Electricity Production in 1951

The total generating capacity of electrical plant installed by all the public electricity supply undertakings in India at the end of 1951 aggregated 1835MW according to the statistical data published by the Central Water and Power Commission last month, covering 415 supply undertakings all over the country. Of the total, which represents an overall increase of 7·2 per cent over the previous year, 1097MW consisted of steam plant, 575MW of hydro plant and the remaining 163MW of diesel plant. The increase in diesel and steam plants was a little over 9 per cent, while that for hydro was near about 3 per cent. There were 514 individual generating stations in operation during 1951 of which thirty-nine were hydro, eighty-six steam and the rest diesel plants. Twenty-four undertakings owned stations with installed capacities exceeding 10MW, contributing over 91 per cent of the electricity produced in the country. Fifty-two undertakings, producing 6¼ per cent of the total energy, had installed capacity between 1MW and 10MW, while the rest, accounting for about 2½ per cent of the total, were below 1MW. Forty-two of the major seventy-six undertakings are state-owned, the majority of the small-scale plants being, however, owned privately.

Electricity production during the year amounted to 5858 million kWh, of which 47·4 per cent was generated by steam plant, 48·8 per cent by hydro stations and the rest by diesel plants. The increase of nearly 15 per cent in the total production (as compared with the 4 per cent increase in the previous year) was mainly due to an increase in generation from the hydro (13·5 per cent) and the steam plants (16·4 per cent), the outputs from the smaller diesel plants remaining practically steady. There were only thirteen undertakings generating more than 100 million kWh and these contributed 83 per cent of the total power. Twenty-four undertakings with capacities between 10 million and 100 million kWh accounted for 11·7 of the production.

The total number of consumers in India at the end of the calendar year 1951 was 1,678,000, a rise of 177,000 over the previous year. These consumers had a total connected load of 3073MW, an increase of 7·5 per cent. On a *per capita* basis, the average consumption was 13·25kWh (corresponding to 16·25kWh of production) as compared with 10·11kWh for the previous year (U.K. figure for 1951 is about 1180kWh per head). The report excludes production from industrial and railway plants, which, it is stated, would bring the consumption figure to 21kWh. The railways generated about 1777 million kWh and the industrial plants 1656 million kWh.

As in the previous years, the textile and jute industries continued to be the largest purchasers of electricity and generated only a small proportion in their own plants. Cement, iron and steel, fertilisers, paper, sugar, copper and chemical industries, however, continued to meet most of their power requirements from their own stations.

Indus River System

The Indus system of rivers, the distribution of whose waters between India and Pakistan is in dispute, consists of the main River Indus, five tributaries from the east—the Jhelum, the Chenab, the Ravi, the Sutlej and the Beas—and a few tributaries from the west, the most important of which is the River Kabul. The main River Indus rises in Tibet and after flowing through Kashmir, enters Pakistan tribal territory. The valley of the river in its upper part is separated from the rest of Kashmir by very high mountains. The River Jhelum rises in Kashmir and enters Pakistan long before it emerges from the hills. The River Chenab rises in the Punjab (Indian) and, after flowing through Himachal Pradesh and the Jammu district of Kashmir, enters Pakistan soon after it emerges from the Himalayas. The Rivers Ravi and Sutlej pass at first through India and then through Pakistan; the River Beas, the last tributary from the east, lies wholly within India. The western tributaries lie in Afghanistan and Pakistan.

The Basin includes Kashmir, Punjab (India), Himachal Pradesh, Pepsu and Rajasthan in India, and the North-West Frontier Province, Punjab (Pakistan), Sind and Baluchistan in Pakistan. It is an arid area in which the annual rainfall varies from about 30in in the sub-montane tracts to about 5in in the Kathiawar Desert. The greater part of the basin has good soil but successful cultivation is generally not possible without the aid of irrigation. An elaborate canal system has been developed over a number of years, twenty-three being perennial canals of which two lie in India, twenty in Pakistan and the remaining one is divided between the two. Of the eight non-perennial canals one lies in India and the rest in Pakistan. Although, however, the canals lie in Pakistan, the headworks at Ferozepur are situated in India, thus creating complications in the proper distribution of water.

Meanwhile a number of new engineering works are under construction in the basin, both in India and Pakistan. In India, work is progressing on the Bhakra-Nangal project, which will store the waters of the River Sutlej. A new headworks has been built at Harike, 50 miles above Ferozepur, to provide a new source of supply for the eastern canals. It is also proposed, as a part of the comprehensive plan, to divert a small proportion of the total flow of the River Chenab from the upper reaches of the river in Himachal Pradesh and to lead the waters through a tunnel into a tributary of the Ravi, and then through a link canal from the Ravi to the Beas. The main object is to provide irrigation to large areas of undeveloped and under developed lands in the famine affected areas of Rajasthan, bordering on the Kathiawar Desert.

Pakistan has also been going ahead with its plans and has just completed the construction of a link canal from the River Chenab across the Ravi to feed the areas of the Bari Doab canal which now receive water from India. A big barrage on the River Indus, near Hyderabad, is nearing completion, together with a vast network of canals which, in addition to providing assured supplies to the existing inundation canals, will irrigate an additional area of about 2,000,000 acres. Two more big barrages on the River Indus are also to be put in hand very shortly. A new dam and a canal are under construction on the River Kurram, a western tributary of the Indus, and a dam on the Kabul River for irrigation and hydro development will also be put in hand shortly. The dispute over the waters has, if anything, only stepped up the tempo of utilising the natural resources of a basin through which runs the longest river of the Indian sub-continent.

Boats for the Royal Yacht

The boat complement of the Royal yacht "Britannia," which is being fitted out at the yard of John Brown and Co., Ltd., will include a Royal barge, two 35ft admiral's barges, two 27ft. jolly boats, and two 32ft motor cutters. The Royal barge is a 40ft barge built by Vosper, Ltd., and is the smaller of the two existing Royal barges, while the motor cutters are of standard design. However, the 35ft medium-speed admiral's barges and the 27ft jolly boats are being built to new designs prepared by the Director of Naval Construction.

The admiral's barge has a length overall of 35ft by 9ft breadth moulded by 5ft 7in depth moulded and weighs 5·5 tons in the light condition and 7·5 tons when loaded and has a carrying capacity of about thirty persons. Twin Foden F.D. 4 diesel engines fitted with a two-to-one reduction gear and each developing 70 b.h.p. at 1800 r.p.m. give the boat a speed of 12 knots. Round bilge form has been adopted and the hull planking is of double-skin mahogany with the outer skin laid in fore and aft strakes and the inner skin laid diagonally over closely spaced transverse timbers laid outside longitudinal stringers. To give added rigidity to the framing system between transverse bulkheads, riding timbers are worked at wide intervals inside the stringers and all timbers and stringers are of Canada Rock elm. For the main transverse bulkheads and canopies extensive use is being made of plywood bonded with phenol formaldehyde synthetic glue.

Pulling and sailing boats have been the traditional sea boats of the Royal Navy, but their inability to make progress against wind and sea, the development of suitable engines and the requirement for motor sea boats having the ability to work to windward under power has resulted in a new design of jolly boat. This has a hull which is fully buoyant when swamped and the following main particulars: length between perpendiculars 27ft, breadth moulded 7ft 7½in, depth 3ft 7in, weight in light condition 3·25 tons and carrying capacity of twenty-six persons. A single Perkins P.4 diesel engine with a two-to-one reduction gear is fitted and has a rating of 35 b.h.p. at 1200 r.p.m. to give the boat a speed of 6 to 7 knots. A watertight aluminium alloy casing encloses the engine so that it is capable of running when the boat is swamped, and a closed circuit cooling water system with outside keel heat exchangers enables the engine to be started up when the boat is in davits. The boats are fitted with an elaborate system of buoyancy tanks, which are constructed in "Fibreglass" plastic material.

Chemical Engineering Conference

A CHEMICAL engineering conference arranged by the Institution of Chemical Engineers and the Chemical Engineering Group will be held at Olympia, in London, during the Engineering, Marine and Welding Exhibition, and the Chemical Plant Exhibition, from September 7 to 11, 1953.

The conference, which will be open to all visitors, will be opened on Monday, September 7th, by Mr. S. Robson, the president of the Institution of Chemical Engineers. On the afternoon of that day two papers will be presented, one "Carbon and Graphite as Materials of Construction for Chemical Plant," by Messrs. A. W. Morrison, B. W. Freedman and P. G. R. Haines, and the other, "Tantalum and Zirconium: Production and Properties," by Dr. G. L. Miller.

On the afternoons of the four succeeding days papers will be presented on "Developments in the Production of Chlorine with Special Reference to Mercury Cells," by Mr. L. R. Thomas; "Recent Advances in Milk Processing Plant," by Mr. J. C. F. Renton; "Recent Developments in Evaporation, with Particular Reference to Heat Sensitive Liquids," by Mr. B. N. Reavell; "Recent Advances in Distillation," by Mr. G. A. Dummett and Dr. P. V. Clifton; "The Production of Formaldehyde from Methanol by the Silver Catalyst Process," by Mr. Nickels, and "Recent Developments in the Application of Plastics to Chemical Plant," by Mr. Verney Evans.

"Avon" Turbo-Jet Engine Development

AN announcement from Rolls-Royce, Ltd., states that one of the "Avon" series of turbo-jet engines, the "R.A.14," has been type tested at 9500 lb static thrust without reheat. These tests were conducted last April and production and delivery of this engine have already begun only twenty months after running the first engine. The company states also that later engines in the "Avon" series are developing in the air thrusts well in the five-figure category. It is claimed by Rolls-Royce, Ltd., that the "R.A.14" engine achieves a greater thrust per unit of frontal area than any known turbo-jet engine.

Industrial and Labour Notes

Employment Figures for June

According to the Ministry of Labour and National Service estimates there was no change in the total number of the working population during June last.

The strength of the Forces decreased by 2000 to 865,000 and the number of ex-Service personnel on release leave who had not entered employment at the end of the month was about 5000.

At July 13th the total number of persons registered as unemployed was 272,700 (of whom 15,300 were temporarily stopped) and the total showed a decrease of 25,100 from the figure as at June 15th. Of this total 126,000 persons had been unemployed for more than eight weeks. Unemployment represented 1·3 per cent of the estimated total number of employees compared with 1·4 per cent in June and 1·9 per cent in July, 1952.

During June the number of persons in civil employment (industry, commerce and services of all kinds) increased by 23,000, mainly women. In the basic industries employment rose by 7000, principally due to seasonal increases in agriculture and fishing, and there was a decline of 1000 in the number of wage-earners on colliery books. Employment in the manufacturing industries showed little overall change during the month and decreases in employment included 8000 in engineering, metal goods and precision instrument trades.

Export of Semi-Manufactures of Copper and Copper Alloys

The Board of Trade has announced that, in view of the improvement in supplies of copper, it is no longer necessary to restrict the export of semi-manufactures of copper and copper alloys on supply grounds.

As has recently been announced, under changes in export licensing control made by a Board of Trade Order effective on August 5th, semi-manufactures of copper and copper alloys may now be exported to the Commonwealth (excluding Hong Kong), U.S.A. and Irish Republic without licence. For exports to other destinations export licences remain necessary but will be granted freely subject to strategic considerations.

Trade Unions To-day

Realising the general need for greater clarity on the facts of the trade union movement, the British Institute of Management has published a booklet in which three prominent trade unionists give an account of trade union history, organisation, functions, relationship with Government and industry, and attitude to the problems of the day. This book is reproduced from a series of three talks which the Institute arranged earlier this year in consultation with its Trade Union Advisory Committee. The speakers were Sir Vincent Tewson, general secretary of the Trades Union Congress ; Mr. Tom Williamson, general secretary of the National Union of General and Municipal Workers and member of the Trades Union Congress General Council, and Mr. J. A. Birch, general secretary of the Union of Shop, Distributive and Allied Workers, and member of the Trades Union Congress General Council.

In his paper, as reprinted in the book, Sir Vincent Tewson deals with " The Relationship of the Trade Union Movement to Government and Industry," and first gives some interesting statistics on the composition and history of the Trades Union Congress. He points out that there are 700 trade unions in this country, of which only 186 are affiliated to the T.U.C., but those 186 have 8,000,000 members, as against 1,000,000 between all the other unions. Since its inception in 1868, the Trades Union Congress has had dealings with the Government of the day. The struggle for recognition by State and employers lasted from the beginning of the movement until almost the beginning of the last war, says Sir Vincent, but the second phase has now been reached—the acceptance of responsibilities. Before the outbreak of the war the T.U.C. pledged its wholehearted support to the Government, and the consultative machinery that was built up then, between employers, workers and Ministers, continues to develop to-day, and has made possible the revolutionary post-war policy of trade union support of both wage restraint and productivity. Mr. Tom Williamson's paper " Trade Unions at Work," is a concise and detailed survey of how a modern trade union is administered and operated.

The last paper, contributed by Mr. J. A. Birch, deals with " Trade Unions and the Problems of Wages," and in his examination of the problems the author covers the sharp struggles of the Industrial Revolution, and deals with the extent to which these old conflicts have been modified by the social development of the Welfare State.

National Insurance (Industrial Injuries) Act, 1953

The National Insurance (Industrial Injuries) Act, 1953, which will come into operation on August 26, 1953, makes a number of beneficial changes in the scheme of insurance against industrial injuries whilst leaving the main structure of the scheme unaltered. There is no increase in contributions.

The Industrial Injuries scheme, established by the National Insurance (Industrial Injuries) Act, 1946, which came into operation on July 5, 1948, replaced the Workmen's Compensation Act by a new system of compensation for accidents at work and for " prescribed " industrial diseases. Under this Act for the first time compensation took the form of insurance benefits under a State-administered scheme.

Immediately after an accident injury benefit can be paid for a limited period during incapacity for work. This may be followed by disablement benefit, which is either a pension or a gratuity and which depends on a medical assessment of the severity of the disablement and not on loss of earnings. This basic benefit can be supplemented by various allowances. The main change under the new Act is a relaxation of the conditions for disablement benefit. At present this benefit can only be paid if the disablement resulting from the accident or industrial disease is substantial, that is, assessed by a medical board at 20 per cent or more, or likely to be permanent, or in some circumstances both substantial and permanent. From August 26th next the benefit may be paid wherever the disablement is assessed at 1 per cent or more, whether it is permanent or not.

Titanium Production Project

THE Ministry of Materials announces that it has recently concluded a contract with Imperial Chemical Industries, Ltd., under which the company will at its own expense erect capacity to produce 1500 tons of sponge titanium a year. The company will also install capacity for converting this metal to ingot form, and it expects production to begin in two years' time. The Ministry has undertaken to buy directly up to three-quarters of the company's output of sponge titanium over the first four years of production if the metal is not otherwise sold in various forms for use by Government contractors. The Ministry has an option on the full output if needed for defence purposes. The price of the metal will be equivalent to the world price current at the time of purchase.

Apart from this project, the Ministry understands that I.C.I. already has in course of erection pilot plants which will begin to produce at the rate of 150 tons per annum early in 1954.

The Effect of Holidays on Coal Output

Coal production in this country dropped heavily as a result of the miners having two weeks' holiday for the first time. Total production during the week ended August 1st fell to 2,253,200 tons compared with 3,238,300 tons the previous week and 2,835,900 tons the corresponding week of last year. Holidays accounted for a loss of 2,152,000 tons compared with 1,243,700 tons in the week ended July 25th. Deep-mined output during the week ended August 1st totalled 2,042,400 tons, compared with 3,001,500 tons in the previous week, open-cast sites yielding 210,800 tons compared with 236,800 tons in the previous week.

In the first thirty weeks of this year, production was 1,790,000 tons below that of the first thirty weeks of 1952, at 128,412,400 tons. Holiday losses have accounted for 8,966,600 tons compared with 5,247,100 tons last year.

Steel Supply to the Shipbuilding Industry

Speaking at a luncheon which followed the launching of a vessel at Belfast this week, Sir Frederick Rebbeck, the chairman and managing director of Harland and Wolff, Ltd., complained about the supply of steel plate to the shipbuilding industry. He said that, as things were, there would not be a plate in Belfast with which to lay the keel of another ship until next January. Despite statements about the improvements in steel production the delivery of plates to shipbuilders was not much better. His firm had just received its allocation of plate under the new voluntary distribution scheme which was due to take effect in October, and it showed no appreciable increase in the amount of plate above what was being received at the present time. The firm was also experiencing delays through not being able to obtain materials in the order in which they were required, and this made it impossible to build ships any faster.

Railway Wage Claims

The three railway unions last week presented a joint claim for an increase of 15 per cent in the wages of railway workers to the Railway Executive. The Executive promised to give an early reply to the claim. Estimates as to what it will cost to meet the claim in full vary from £20 to £50 million a year. This claim (put forward by the National Union of Railwaymen, Associated Society of Locomotive Engineers and Firemen and the Transport Salaried Staffs Association) is based upon the cost of living and the need to bring railway workers' pay into line with that of other industries.

World Tin Conference

It is reported in the *Financial Times* that a decision will be taken soon as to whether the principal tin producing and consuming nations of the world will meet again to discuss an international scheme for the metal. The report points out that since January this year the price of tin has dropped from nearly £1000 a ton to its present price of about £575 a ton. This has made production of tin uneconomic in many areas and led to the closing down of a number of gravel-pump mines in Malaya. In the first half of the year it is estimated that world tin output exceeded consumption by some 17,800 tons—or an annual rate of surplus of over 36,000 tons—excluding strategic stockpiling, which absorbed some of the surplus. World consumption of tin during the first half of the year is estimated at 67,200 tons, of which 30,000 tons was used in the United States and 9320 tons in this country.

Conference of Industrial Research Directors and Managers

The report has just been published of the third conference of Industrial Research Directors and Managers, which was organised by the Federation of British Industries and held at Ashorne Hall, Warwickshire, in April last. The general theme of this conference was the vital need to make full commercial use of research and discovery, and it was opened by Lord Baillieu, who spoke on the commercial utilisation of research results as a company management problem. The report reproduces the introductory papers and gives summaries of the discussions at the conference. It can be obtained from the offices of the Federation of British Industries, 21, Tothill Street, London, S.W.1, price 3s. 6d. net.

Notes and Memoranda

Rail and Road

BRITISH TRANSPORT COMMISSION CHARGES SCHEMES.—The Minister of Transport, the Rt. Hon. Alan Lennox-Boyd, M.P., has granted the application of the British Transport Commission for a further period of two years, from August 6, 1953, for the preparation and submission to the Transport Tribunal of the Commission's draft Charges Schemes. A Passenger Charges Scheme is already in force, but the further period of two years is required for the preparation and submission of draft schemes relating to other charges, in view of the changes effected by the Transport Act, 1953, particularly those affecting the nature and content of Charges Schemes.

Air and Water

ADMIRALTY SHIP WELDING COMMITTEE REPORT.—A limited number of copies of the "S.S. 'Ocean Vulcan' Sea Trials, Report No. R.8," prepared by Mr. F. B. Bull and published by Her Majesty's Stationery Office for the Admiralty Ship Welding Committee, are available for loan or scrutiny in the Department of the Chief of Naval Information, Admiralty. This report is one of a series of investigations into a comparison of the structural behaviour of welded and riveted ships under the forces experienced at sea. The report covers measurements made on S.S. "Ocean Vulcan" a welded tramp vessel of 7174 gross tons, during sixteen crossings of the Atlantic from December, 1945, to May, 1947. It refers to ocean waves, earlier measurements of strain at sea, planning of sea trials on the vessel, instrumentation, voyages undertaken and a discussion of the data obtained and methods employed. Applications for the report should be made personally to the Department of the Chief of Naval Information, Admiralty, Whitehall (Room 23, West Block, Ground).

Miscellanea

THE BRITISH INTERNAL COMBUSTION ENGINE RESEARCH ASSOCIATION.—It is announced that Mr. H. Norman G. Allen has been re-elected chairman of the council of the British Internal Combustion Engine Research Association for the current year.

EUROPEAN MACHINE TOOL EXHIBITION COMMITTEE.—Four representatives of the manufacturers' section of the Machine Tool Trades Association have been elected as delegates to the European Committee for Co-operation of the Machine Tool Industries. The members elected were Mr. Robert W. Asquith, Mr. H. J. D. Kearns, Mr. W. J. Morgan, and Mr. R. D. G. Ryder.

DOUBLE HELICAL GEAR BROCHURE.—We have received from Turbine Gears, Ltd., Cheadle Heath, Stockport, an illustrated brochure outlining its design, manufacturing and technical services. The technical information afforded in the second half of this brochure includes design and performance data of double helical and spur gears, specifications, heat dissipation, lubrication, horse power ratings and worked examples of size selection.

THE LATE SIR JOHNSTONE WRIGHT.—A memoria service for the late Sir Johnstone Wright, a past-president of the Institution of Electrical Engineers, will be held at the Queen's Chapel of the Savoy, Savoy Street, W.C.2, at 12.30 p.m. on Monday, August 24, 1953. The service will be conducted by the Rev. Prebendary E. H. Williams-Ashman, M.V.O., M.A., and a short address will be given by Sir John Hacking, past-president of the Institution and deputy chairman (operations) of the British Electricity Authority.

NATIONAL DIPLOMA IN AGRICULTURAL ENGINEERING.—The examination board appointed by the council of the Institution of British Agricultural Engineers has announced the results of the third examination for the National Diploma in Agricultural Engineering, held at the Essex Institute of Agriculture, Writtle, Chelmsford, in July last. Twenty-four candidates presented themselves for examination, of whom four were re-admittances from 1952. Fourteen candidates were awarded the diploma, five failed in one subject and five failed the entire examination. No candidate gained distinction.

THE PURCHASING OFFICERS' ASSOCIATION.—The Purchasing Officers' Association, which now has over 3000 members and students holding responsible purchasing positions in industrial and public undertakings, has just published a new list of members. The new booklet includes full details of the growth and activities, membership regulations and examination syllabuses of the association and is divided into separate sections covering the United Kingdom, Australia and South Africa. In each case an index of firms is provided. We are informed that a limited number of the lists are available, price 5s. net, from the Secretary of the Association at Wardrobe Court, 146a, Queen Victoria Street, London, E.C.4.

HEAT TREATMENT OF ALUMINIUM ALLOYS.—We have received from the Northern Aluminium Company, Ltd., Banbury, a copy of a small book entitled "Heat Treatment of Aluminium Alloys," which is a reprint of an earlier edition, but incorporating revisions resulting from experience gained during the last five years. The booklet deals with the theory of heat-treatment, including solution heat-treatment, precipitation heat-treatment and annealing, and then goes on to discuss the practice of heat-treatment, touching upon general considerations, such as temperature range, overheating and treatment periods. There are sections upon furnaces, temperature measurement and control, quenching methods, refrigeration, and annealing. The booklet concludes with two appendices, one noting the alloy and temper designation system of the company and the other setting out, in tabular form, the heat-treatment procedures for wrought and casting alloys.

FELLOWSHIP OF THE CITY AND GUILDS OF LONDON INSTITUTE.—The Council of the City and Guilds of London Institute has conferred the Fellowship of the Institute (F.C.G.I.) upon a number of past students of the City and Guilds College (the engineering section of the Imperial College) in recognition of the contribution each has made to the advancement of the industry in which he is engaged. The past students are: Mr. L. P. Coombes, chief superintendent of the Aeronautical Research Laboratories of the Australian Department of Supply and Development; Brigadier L. H. Harris, Controller of Research of the General Post Office; Mr. R. T. James, of R. T. James and Partners; Mr. J. Davidson Peattie, deputy chief engineer, British Electricity Authority; Sir Robin Rowell, chairman and managing director of R. and W. Hawthorn Leslie and Co., Ltd.

A BOW-END CHUTE FOR COLLIERIES.—A bow-end conveyor chute which is reversible and can be used to receive coal from either left or right-hand conveyors has been developed at Brancepeth Colliery, Durham, to the designs of Mr. R. Bowser, the enginewright at the colliery. Based on the conventional bow-end transfer chute, this unit has the inside tray which receives the coal pivoted so that it can easily be adjusted to deliver in either direction. This enables one chute to be used at either end of a coal face. A modification of the Crossland conveyor control incorporated in the design consists of a hinged tray over which the coal passes from the delivery belt. The conveyor runs so close to the lip that any faulty joints or tears in the belt will tip the tray, which in turn operates a cutout switch. The chute is fitted to the standard Huwood BB15 drive head. It is stated that five of these chutes are in constant use in the Ballarat seam at Brancepeth Colliery, and there has been no loss of coal through damaged belts since their introduction.

"NOVAL" BASED VALVES FOR AUDIO AMPLIFIERS.—Using two valves recently introduced by Mullard, Ltd., Century House, Shaftesbury Avenue, London, W.C.2, it is possible to design a complete audio amplifier using valves with the Services preferred "B9A" (Noval) base. The new valves are the "EL84" high sensitivity output pentode and the "EZ80" full-wave rectifier. The other valves in the series comprise the "EF86" voltage amplifying pentode; three double triodes "ECC81," "ECC82," and "ECC83." The "EL84" valve is a high sensitivity output valve, rated to dissipate 12W at the anode, compared with 9W for the "EL41" which it replaces, the heater rating being 6·3V, 0·8A. The grid input is less than 4V and the "EL84" will deliver over 5W of audio power at 10 per cent total distortion; a push-pull pair of "EL84" valves in class "AB1" will deliver 16W output. The characteristics of the "EZ80" full-wave rectifier are identical with those of the "EZ40"; it is capable of a rectified output of 90mA, the maximum input voltage being 2×350V r.m.s. The heater is rated at 6·3V, 0·6A.

DEATH OF COMMANDER Q. H. BULLARD.—It is with regret that we have to record the sudden death of Commander Quinton H. Bullard, until a month ago managing director of Marconi (South Africa), Ltd. Commander Bullard began his career in communications with the South African Post Office and later joined Cable and Wireless, Ltd. He was actively interested in radio communications for the whaling fleets, and this interest led to his reclaiming Heard Island—now occupied by Australia—for the British Government in 1929. The following year he landed on uninhabited Marion Island, about 1200 miles south of Cape Town, and established a system of radio communication between the island and the Union. This radio link made possible the transmission of weather reports from the sub-Antarctic and paved the way for the establishing of a weather station and the subsequent occupation of Marion and Prince Edward Islands. Commander Bullard's direct association with the Marconi Marine Company began in 1937, when he was appointed as the company's representative in Cape Town. In 1945 Commander Bullard became managing director of the company then handling Marconi Marine business in South Africa, the Wireless Agency, Ltd., later changed to Marconi (South Africa), Ltd. Ill-health forced him to relinquish some of his duties, and he resigned at the end of June last, continuing to act as marine manager and technical consultant whilst retaining his seat on the board as a director.

MINIATURE 1·4V BATTERY VALVES WITH REDUCED FILAMENT CONSUMPTION.—A range of miniature "B7G" battery valves recently introduced by Mullard, Ltd., Century House, Shaftesbury Avenue, London, W.C.2, should be of interest to designers of battery-operated receivers in which low battery drain is important. The filament consumption of these new Mullard valves is half that of previous comparable valves, being 1·4V, 25mA for the frequency changer, I.F. amplifier and A.F. amplifier, and 1·4V, 50mA for the output valve. The range comprises the "DK96" frequency changer, the "DF96" i.f. amplifier, the "DAF96" diode a.f. pentode, and the "DL96" power output valve. The valves are similar in construction and appearance to the miniature seven-pin all-glass valves generally used in battery sets. They are designed primarily for use in receivers with filaments connected in parallel, but they may be used in a 50mA series chain with two 25mA filaments in parallel or one shunted by a resistor. The "DK96" is a self-oscillating heptode frequency changer similar to "DK92" in its mode of operation; the conversion conductance is 0·3mA/V. The "DF96" valve is a variable-mu h.f. pentode suitable for use as a controlled i.f. amplifier; it has a mutual conductance of 0·75mA/V for a total cathode current of 2·2mA, and is fully controlled by −5·5V at the grid. The "DAF96" valve is a short grid base pentode for a.f. amplification, combined with a single diode for use as a detector; the a.f. gain is 65 in a typical circuit. The "DL96" valve is an output pentode having two filament sections which may be connected in series or in parallel; it will deliver 200mW into a 13 kilohm load, the total h.t. drain being 5·9mA.

Contracts

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has received an order for extending the capacity of Catalagzi power station, Turkey, by 60MW, which will double the size of the original power station, built and equipped after the war by the same company acting as main contractors. The value of the new order is about £3,500,000 and it covers the supply of three 20MW turbo-generator sets, three boilers, and the necessary switchgear, transformers and auxiliaries, together with the complete extensions to the buildings. Main sub-contractors are Babcock and Wilcox, Ltd., for boiler-house equipment and Braithwaite and Co., Engineers, Ltd., for civil engineering work; the steelwork for the buildings will be supplied by Dorman, Long and Co., Ltd. Catalagzi power station, which has been running for nearly four years, supplies power to the coalfields at Zonguldak on the Black Sea, and it is also linked by a 200-mile transmission line to Istanbul. The new extensions are believed to be required to deal with the increased demand for electricity from Ankara.

Personal and Business

MR. THEODORE BERRY, A.M.I.Mech.E., A.M.I.Mar.E., works manager of Drysdale and Co., Ltd., of Yoker, Glasgow, has been appointed a director of the company.

MR. A. E. BAGG has left Industrial Guarding Equipment, Ltd., to take up his appointment as managing director of Press Guards, Ltd., at Farm Street, Birmingham.

THE appointment has been announced of Mr. F. G. H. Foreman as director and general manager of A. Luson and Sons, Ltd., Gem Works, Minerva Road, N.W.10, the manufacturers of industrial wire brushes.

MR. H. WATSON SMITH, C.B.E., has succeeded the late Earl Granville, K.G., as chairman of the Lilleshall Company, Ltd., and the Lilleshall Iron and Steel Company, Ltd. The present Earl Granville has been appointed deputy chairman.

MR. A. L. CRAMB has been appointed manager and will be responsible for the branch office in India of the Brush Electrical Engineering Company, Ltd., Loughborough. He will have the status of a local director (in India) and remains a director of Brush Export, Ltd.

BIRMID INDUSTRIES, Ltd., announces the retirement of Mr. Frank G. Woollard from the boards of the Birmingham Aluminium Casting (1903) Company, Ltd., and the Midland Motor Cylinder Company, Ltd., with whom he has been associated as a director for seventeen years.

THE Minister of Supply has appointed Air Chief Marshal Sir John W. Baker, K.C.B., M.C., D.F.C., as Controller of Supplies (Air) at the Ministry of Supply in succession to Air Marshal Sir John N. Bootham, K.B.E., C.B., D.F.C., A.F.C., with effect from October 15, 1953.

WILLIAM JESSOP AND SONS, Ltd., and J. J. SAVILLE AND CO., Ltd., have opened a new area office to direct selling activities of their Lancashire and Yorkshire territories. This office is under the control of Mr. H. Carr and is at York House, 12, York Street, Manchester, 2 (telephone number, Manchester Central. 9184).

COCKBURNS, Ltd., of Cardonald, Glasgow and North Shields, announces that a London office has been opened at 175, Piccadilly, London, W.1, under the management of Captain (E) G. R. Cook, O.B.E., D.S.C., R.N. (Retired). This office will deal with the sales and maintenance for the London area and Home Counties.

DR. FRANCIS F. JARAY has resigned his position of technical director of Tanks and Linings, Ltd., and set up as a consulting engineer specialising in the development of corrosion-proof materials and their application to industrial plant and equipment of all kinds. Dr. Jaray's present address is Martley, Worcs (telephone number Shelsley Beauchamp 271).

W. H. DORMAN AND CO., Ltd., Stafford, has appointed as resident factory representative in Canada Mr. Robert Onions, A.M.I.Mech.E., 44, Grenview Boulevarde South, Toronto, 18. The following firms have been appointed distributors for Dorman products in Canada:—A. B. Wing. Ltd., 1383, Hornby Street, Vancouver, 1; The Dale Equipment Company, Ltd., 1524, Erin Street, Winnipeg; Modern Machinery, Ltd., 120, Fourth Street West, Quebec; and Contractors' Machinery and Equipment, Ltd., 194, Barton Street East, Hamilton.

IT is announced by the Brush Group of companies that Mr. H. B. McAuslan has been appointed resident representative in India, Pakistan and Burma. Mr. McAuslan will travel to India to take up his new duties at the end of August. He has been made a director of Associated British Oil Engines (Export), Ltd., Aboex, National Oil Engines (Export), Ltd., Noex and Brush Export, Ltd. Mr. McAuslan's new duties are the supervision of Aboex and Noex, agents in the Indian sub-continent, Pakistan and Burma, and of Brush Export agents in Pakistan and Burma. He will be responsible to Mr. J. P. Ford, managing director of Aboex, Noex, and Brush Export.

British Patent Specifications

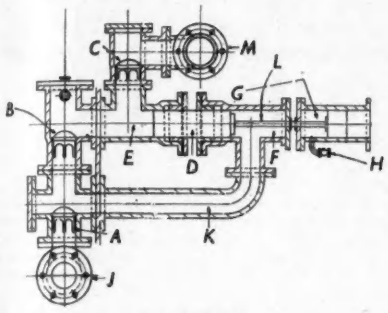
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 6d. each.

PUMPS

693,901. January 30, 1950.—RECIPROCATING PUMPS, William Phillips, 9, Cross Road, Dyffryn Cellwen, near Neath, County Glamorgan.

The accompanying drawing illustrates a pump in accordance with the invention, in which two barrels are provided. The drawing is a cross sectional elevation of one of the pump barrels in which *A* is the suction valve, *B* is the intermediate valve, *C* is the delivery valve, *D* the plunger, *E* delivery end of the barrel, *F* suction end of barrel, *G* compressed air cylinder, *H* air suction check valve, *J* suction branch pipe, *K* suction communication pipe, *L* plunger rod. A displacement of plunger *D* in the suction end of the barrel draws the liquid in it through the suction branch pipe *J*, suction valve *A*, and the communication pipe *K*, the plunger *D* in the return



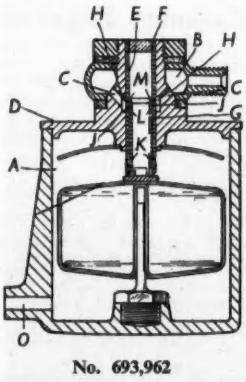
No. 693,901

stroke forces the liquid therein back through the communication pipe *K*, and the intermediate valve *B* to the delivery end of the barrel *E*. There is a provision in the invention for compressed air to be generated in the compressed air cylinder *G* and delivered through the communication pipe and check valve into the intermediate valve box casing *B* attached to the delivery end of the barrel *E*, in which the liquid and air are mixed and delivered through the delivery valve *C* to branch pipe *M*, to the main delivery column. The air is injected into the intermediate valve casing *B* during the same period as the liquid is passing through the intermediate valve. A mixture of air and liquid inside the rising main column is less in weight than an equivalent column of liquid.—*July* 8, 1953.

INTERNAL COMBUSTION ENGINES

693,962. May 14, 1949.—CARBURETTORS, Richard McCandless, 60, Lisburn Road, Belfast, Northern Ireland.

The invention relates to carburettors for internal combustion engines in which the liquid fuel flow is controlled by a float chamber constant level device. The drawing shows a vertical section through the float chamber. Fuel is supplied to the top of the float chamber *A* through a union *B* entering the valve chamber through a ring or circular holes *C* inwardly and downwardly inclined in the valve float chamber



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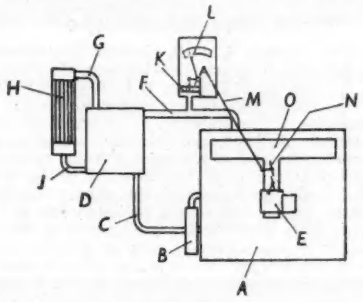
cover *D*. The valve cylinder *E* is formed by a tubular liner *F* pressed into a central bore *G* in the float chamber cover. An annular groove *H* is machined in the bore *G* joining up the inlet ports *J* and placing them in communication with the ring of circular holes *C*. A valve piston *K* has an internal fuel passage *L* which is tapered to form a sharp edge on the upper end *M* of the piston and the passage *L* is closed at the bottom by a foot which forms a bearing resting on and operated directly by the float. The outlet from the passage *L* is formed by gaps cut through the walls of the piston near the foot and when the upper end of the piston masks the inlet ports *J* the lower end of the liner covers the gaps. The end of the liner is externally tapered to form a sharp edge. Fuel is delivered through the outlet *O*. In operation it will be understood that, provided the inlet ports *J* are small in comparison with the bore of the fuel passage *L* and the instantaneous area of the opening of the gaps *O* is always greater than that of the ports *J* so that the passage *L* does not run full, the pressure drop between the fuel supply pressure and the atmospheric pressure in the float chamber takes place substantially at the ports *J* and there is therefore substantially no pressure downstream of the ports able to influence the movement of the piston *K*. The pressure applied to the parts of the piston exposed to the fuel supply pressure through the valve ports is radial and self-balancing around the periphery of the piston. With the port arrangement described large changes in flow can be made for small float movements and provides a valve which is effective in maintaining a substantially constant fuel level in the float chamber for different supply pressures.—*July* 8, 1953.

693,873. August 3, 1951.—LIQUID COOLING WITH EVAPORATION COOLING, Daimler-Benz Aktiengesellschaft, Stuttgart-Unterturkheim, Germany.

The invention relates to a liquid cooling system for internal combustion engines, in which the cooling liquid is heated to evaporation point and recondensed by cooling in a closed circuit sealed off from the atmosphere. As the drawing shows, the cooling liquid, which may be frost-proof, is supplied to the engine *A* by the pump *B* through the pipe *C* from the tank *D*, which at the same time acts as condenser. As illustrated, the engine has a carburettor *E*. In consequence of the waste heat given up by the cylinder walls, the cooling liquid evaporates in the engine and passes in vapour form through the pipe *F* back to the condenser *D*, where the vapours are recondensed. In order to increase the condensing action, a pipe *G* may be connected to the tank or condenser *D* and lead to a radiator *H* which returns the liquid condensing therein back to



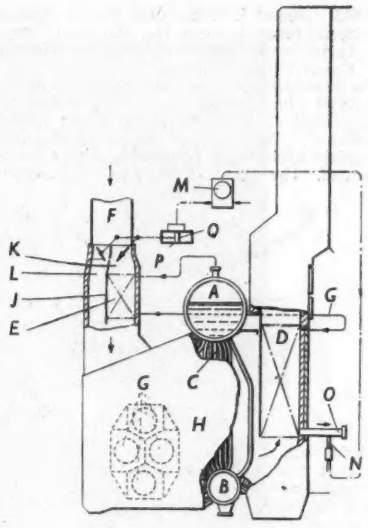
No. 693,873

the tank through a pipe *J*. The whole cooling system is sealed off relatively to the outside atmosphere, so that it is substantially under the evaporation pressure. A pressure transmitter *K*, such as a diaphragm or spring-loaded piston, is connected to the pipe *F* and through a suitable linkage operates an indicator *L*. A warning lamp or an acoustic warning signal may also be operated as soon as the pressure in the cooling system approaches or exceeds a determined permissible height. To the indicator lever is also connected by means of the rod *M* a throttle valve *N* in the admission manifold *O* of the engine. This valve is closed and reduces the power of the engine when the permissible pressure is exceeded. As shown, two throttle valves may be used or these may be combined into one valve. A similar system can be used with diesel engines.—*July* 8, 1953.

STEAM GENERATORS

693,911. March 28, 1950.—WATER TUBE BOILERS, Foster-Wheeler, Ltd., Foster-Wheeler House, 3, Ixworth Place, London, S.W.3, formerly of Aldwych House, Aldwych, London, W.C.2. (*Inventor: Anthony James Taylor.*)

The invention is concerned with automatic control of the final steam temperature but does not necessarily involve desuperheating and resuperheating. As the drawing indicates, the boiler consists primarily of the usual upper steam drum *A* and lower water drum *B* connected by steam generating tubes *C* and a superheater *D* receiving steam from the steam drum. A condenser *E* is provided; it is in the form of an indirect heat exchanger in the duct *F* through which combustion air passes to the burners *G* in the furnace *H* of the boiler. Steam from the steam drum *A* passes through the condenser *E*, which is arranged within an open-ended casing *J* in the duct *F*. Dampers *K* are provided for regulating the air flow, some or all of the air passing through the casing *J* or a by-pass passage *L* in accordance with the temperature of the steam leaving the superheater. The dampers are controlled by a regulator *M* which is influenced by a thermostat *N* in the steam outlet pipe *O* and supplies pressure to a cylinder *P*, the piston Q of which is connected to the dampers. In the boiler shown the superheater *D* is in the form



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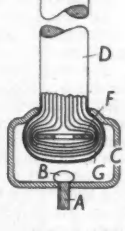
of a single bank of tubes providing a single stage of superheating. The saturated steam from the drum *A* is led to the condenser *E* and thence to the superheater *D*. As the air supply to the condenser depends upon the final steam temperature, so will the amount of steam which is condensed. A mixture of condensate and saturated steam will thus pass from the condenser to the superheater, the steam in that mixture being wetted by the condensate to an extent dependent upon the final steam temperature, which can thus be kept constant. Similar arrangements for two stage superheaters and a boiler with a superheater, desuperheater and resuperheater are also shown in the specification.—*July* 8, 1953.

ROAD TRANSPORT

693,860. March 16, 1951.—ELASTIC BUFFERS FOR HAWSERS OR TRACTION MEMBERS, Friedrich Wilhelm Pass, Senior, and Friedrich Wilhelm Pass, Junior, of the Firm Gummiwerk Pass and Sohn, Schwelm, Westphalia, Germany.

This invention relates to an elastic buffer for insertion in or forming part of a hawser, tow rope or traction member, having a relatively high notch strength. In the drawing *A* represents the ends of the wire rope, which are to be fastened to the frame of the towing and towed vehicles. The facing ends of these portions of wire rope carry thickenings or nipples *B*, with which they engage in coupling sleeves *C*. The two coupling sleeves are connected to one another through an elastic buffer *D*. The buffer consists of a large number of thin rubber threads *E* which run in the longitudinal direction of the rope, in the direction of travel, and are welded to one another in a nozzle under the action of pressure and heat so that the individual threads can no longer or only indistinctly be recognised. On the other hand, the welding is not carried to such an extent that the individual threads are completely dissolved. They are on the contrary, still present in their structure and exert their effect in the high notch strength of the rope so formed, in that they take up tears, cuts or other damage, so that the threads undamaged by the cut reliably prevent any spreading of the tear. Tensile tests on a rope of about 25mm diameter, which was about half cut through, showed that this rope was still able to



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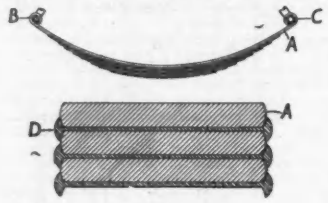
bear a weight of 1000kg and more without tearing any further. Rings of metal *F* at right angles to the longitudinal direction of the buffer are embedded in the two ends *G* of the buffer. The buffer is split longitudinally at the ends; the ring, which naturally may also be a complete disc, is inserted and the material of the buffer is closed up again round the ring by vulcanisation. Instead of the rigid end disc *F* a grommet or thimble can be embedded in the ends of the buffer. Several other embodiments and applications are referred to in the specification.—*July* 8, 1953.

694,113. August 1, 1950.—LEAF SPRING ASSEMBLY, Spring Perch Company, Inc., Hamburg Turnpike, Lackawanna, New York, U.S.A. (*Inventor: Harold Thomas Dow.*)

As illustrated in the drawing, a spring assembly comprises a base spring leaf *A* having its ends rolled as indicated at *B* to receive the spring mounting shackles *C*. The remainder of the spring assembly comprises a number of progressing shorter leaves as indicated. The leaf spring liners (of pliable synthetic



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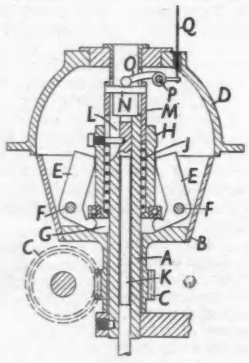
material such as Nylon) comprise strip-like elements *D*, each having flanges formed integrally along the opposite side edges, extending both above and below the body. The flange portions of the liners are shaped at their inboard surfaces so as to fit the side edges of the spring leaves, thereby providing effective seals against ingress of dirt or grit from the roadway between the spring leaves. Various forms of liners are shown in the specification.—*July* 15, 1953.

694,192. October 23, 1950.—VARIABLE-SPEED POWER TRANSMISSION MECHANISMS FOR VEHICLES, The Rover Company, Ltd., Meteor Works, Solihull, Near Birmingham. (*Inventor: Spencer Bernau Wilks.*)

The invention consists of a four-speed variable-power transmission mechanism in which the governor is provided with an adjusting means, which is operable from the exterior of the housing. As the drawing shows, there is provided a hollow pillar *A* mounted on or in the housing of the gearbox. On this pillar is mounted a hollow body *B* which is rotatable from a part of the mechanism in the gearbox by a pair of helical toothed gear wheels *C*. Also on the pillar is a



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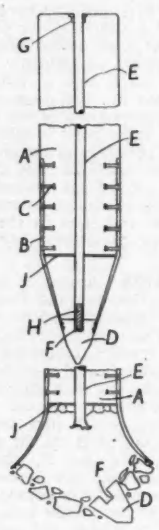
fixed hollow cover piece *D* which, with the part *B*, forms an enclosure for the governor mechanism. This mechanism comprises a pair of centrifugal masses *E* in the form of bell-crank levers pivoted at *F*. The short arms of the parts *E* engage through a ball bearing *G*, a slidable sleeve *H* on the pillar *A* which is loaded by a spring *J*. Motion from the sleeve *H* is transmitted to a slidable gear-changing rod *K* through a pin *L* secured to the sleeve and passing through a slot in the pillar. The abutment which supports one end of the spring comprises a sleeve *M* which is slidable on the pillar and has a slot through which the pin *L* passes. Adjacent to one end the abutment sleeve *M* has a cross pin *N* secured to it on which bears one end of a lever *O* which is pivoted to the stationary part *D* at *P*. To the other end of the lever is attached a member *Q* (which may be a wire cable) through which movement can be imparted to the lever *O* and sleeve *M* from any suitable control lever for varying the compression of the spring *J*, the control lever being situated in any convenient part of the vehicle. By means of the arrangement described the user of the vehicle can readily adjust the setting of the governor to suit his requirements.—*July* 15, 1953.

CIVIL ENGINEERING

693,465. March 8, 1951.—EXPLOSIVE PILE SHOES, William Henry Cundell Blake, Orchard Cottage, Dartington, Totnes, South Devon.

As shown in the drawings a pile *A* is provided at its lower end with a wrought iron shoe *B* secured in position by lugs *C*. The end of the shoe has at its lower end a metal point *D*, preferably of cast iron. A tube *E* extends centrally along the length of the pile, which at its lower end is seated in a recess *F* in the point *D*, whilst at its upper end it has a screwed plug *G* embedded in the pile. When the pile has been driven to a predetermined depth a controlled explosive charge *H* is placed in position through the tube *E* and fired. As a result of the explosion the lower end of the shoe is partly burst open, as shown in the lower view. A cavity is thus formed in the soil at the lower end of the pile which is considerably larger than that formed by a normal pile. Through the tube *E*, cement, concrete or other similar substance can be introduced into the cavity for forming a bed on which the pile can rest. After the explosion the pile may also be driven further downwards, the portions of the shoe forced outwards by the explosion thereby increasing the bearing area. In the case of a concrete pile an insulation joint *J* of compressed fibre is placed between the pile and the charge, the joint being cast integral with the concrete.—*July* 1, 1953.



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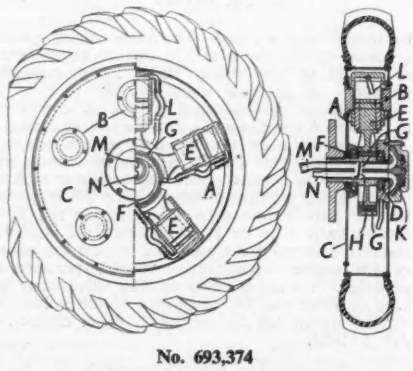
POWER TRANSMISSION

693,374. August 8, 1950.—POWER TRANSMISSION, National Research Development Corporation, 1, Tilney Street, London, W.1. (*Inventors: Henry Joel Hamblin and Francis William Raybould.*)

Referring to the drawings, a number of cylinders *A*, radially disposed, are pivotably attached at *B* to the disc centre *C* of a wheel so that the axis of the cylinders lie in a plane parallel to that of the wheel, and the cylinders rotate with the wheel. The wheel is carried on bearings *D* on a stationary axle and the pistons *E* in the cylinders are connected with an eccentric *F* made integral with or secured to the axle by means of pad bearings *G* on a ring *H* mounted through needle roller bearings *J* on the eccentric. A valve *K* is used to control the transmission of oil



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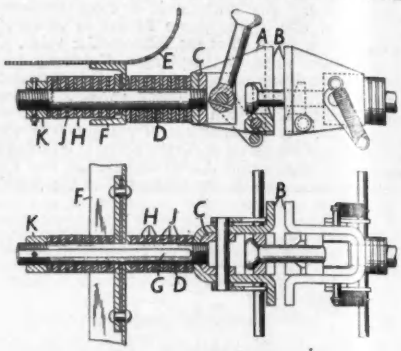
under pressure to all the cylinders, and the escape of oil from them. The reaction between the pistons and the cylinders containing oil under pressure causes the wheel to rotate. The hydraulic medium is admitted to the cylinders through a pipe *L*. It is supplied through the pipe *M*, passing through the centre of the axle past the control valve *K*, and it is discharged through the pipe *N*, arranged within the axle and controlled by the valve *K*. The direction of the rotation of the wheel is reversed by admitting oil under pressure through pipe *N*, and discharging it through pipe *M*. In order to meet agricultural requirements the system includes means for providing two or more distinct ranges of speeds, which are described in the specification.—*July* 1, 1953.

MINING ENGINEERING

694,320. July 1, 1949.—VEHICLE DRAW GEAR, Coal Industry (Patents), Ltd., Hobart House, Grosvenor Place, London, S.W.1. (*Inventor: Ronald Louis John Macrae.*)

The invention relates to draw gear for couplings for rail vehicles, such as mine cars. As the drawing shows, the body of each part coupling comprises a piece of mild steel plate *A* bent to U shape with the ends of the arms turned at right angles to form buffer surfaces *B*. The base of the U is reinforced by a lining member *C* of steel plate bent to shape and screwed into the end of a drawbar *D*. The mouth of the U is directed away from the vehicle *E* towards a companion vehicle. The drawbar passes through a hole in a headstock *F* attached to the underside of



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the body. The drawbar is round with a flat *G* machined on it and the hole in the headstock is of corresponding shape to prevent rotation of the bar and the attached coupling body. The hole is countersunk on both sides to facilitate swinging movement of the drawbar. Threaded on to the drawbar there are two series of alternating rubber and metal washers *H* and *J* between the coupling body and the headstock and the headstock and a nut *K* on the end of the bar. These washers constitute a resilient shock absorbing connection between the coupling and the vehicle. The construction and operation of the coupling forms the subject of Patent Specifications Nos. 694,304, 26,165 and 17,510 and is described in greater detail in the complete specifications filed for those applications.—*July* 15, 1953.

Launches and Trial Trips

ADRASTUS, cargo liner; built by Vickers-Armstrongs, Ltd., Walker naval yard, for Alfred Holt and Co.; length overall 487ft, breadth moulded 62ft, depth moulded 35ft 3in, deadweight 9000 tons, load draught 28ft; gross tonnage 7800; six main cargo holds, service speed 15½ knots; Harland and Wolff-B. and W. diesel engine, seven cylinders, 7000/7600 b.h.p.—Launch, July 22nd.

LUSTROUS, oil tanker; built by Smith's Dock Company, Ltd., for H. E. Moss and Co.; length between perpendiculars 500ft, breadth moulded 69ft 6in, depth moulded 38ft., deadweight 16,700 tons on 29ft 10in draught, service speed 13·25 knots; twenty-seven cargo oil tanks, two cargo pump rooms, four 500 tons per hour cargo pumps, two 100 tons per hour drain pumps, steam deck machinery, two 50kW steam-driven generators; Hawthorn-Doxford two-stroke oil engine, five cylinders, 670mm diameter by 2320mm combined stroke, 5500 b.h.p. at 112 r.p.m., two Scotch boilers. Launch, July 28th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASLIB.

Fri. to Mon., Sept. 11th to 14th.—The University, Nottingham, 28th Annual Conference.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Sept. 30th.—LONDON SECTION: London School of Hygiene and Tropical Medicine, Keppel Street (Gower Street), W.C.1, "The Impact of Communication Theory on Television," D. A. Bell, 6.30 p.m.

ENGINEERS' GUILD

Thurs., Sept. 24th.—METROPOLITAN BRANCH: Caxton Hall, Caxton Street, Westminster, S.W.1, Annual General Meeting, 6 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., Aug. 18th.—Visit by a Party of Members to the works of Scammell Lorries, Ltd., Watford, Herts, 10.45 a.m.

ROYAL AERONAUTICAL SOCIETY

Tues. to Fri., Sept. 8th to 18th.—LONDON: Anglo-American Conference.